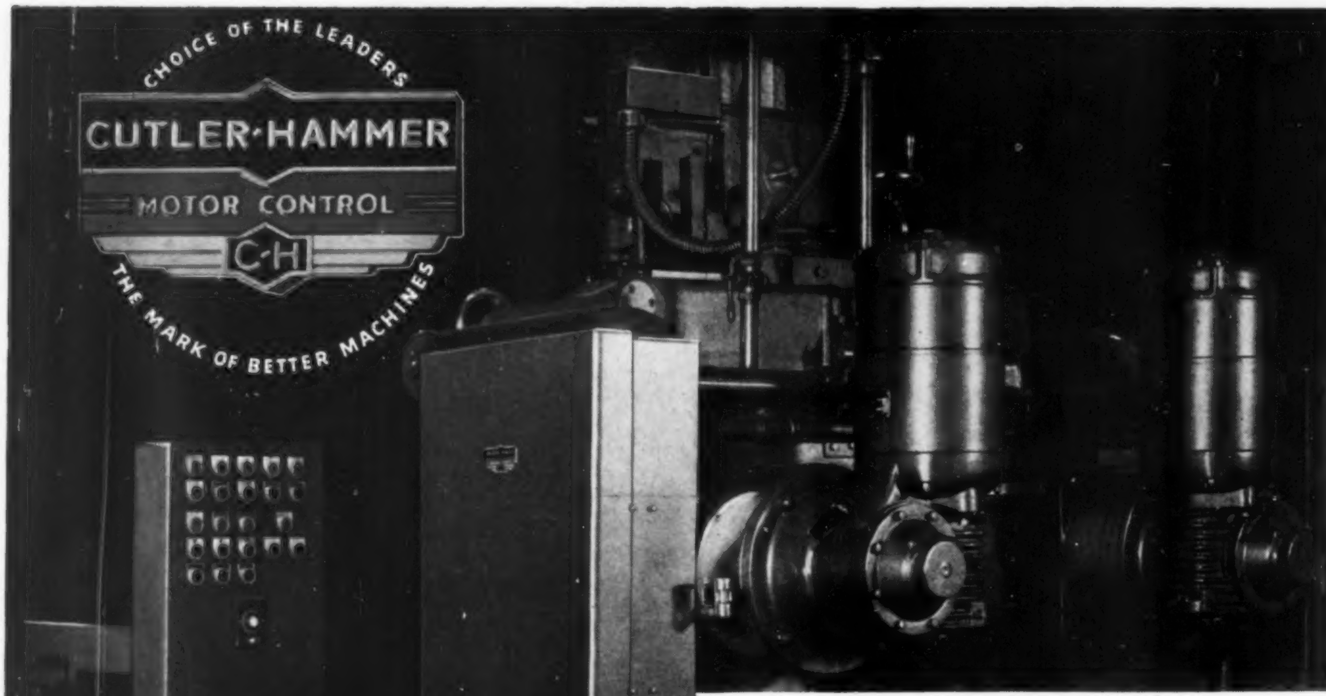
MACHINE DESIGN

February 1951

In This Issue:

COST CONTROL ENGINEERING
STRESS CONCENTRATIONS
COIN-OPERATED CONTROLS

Contents, Page 3



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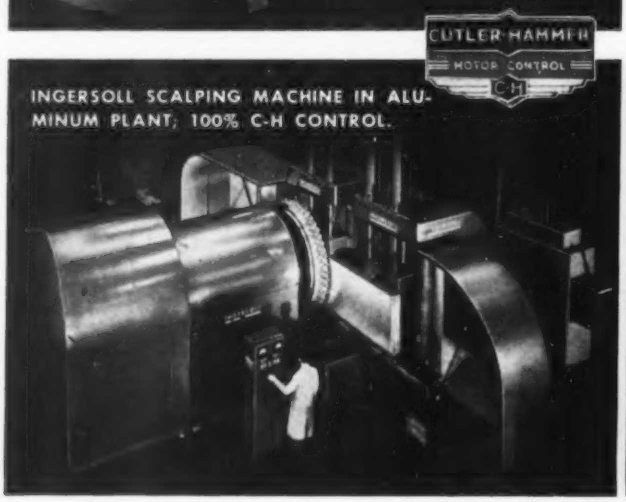

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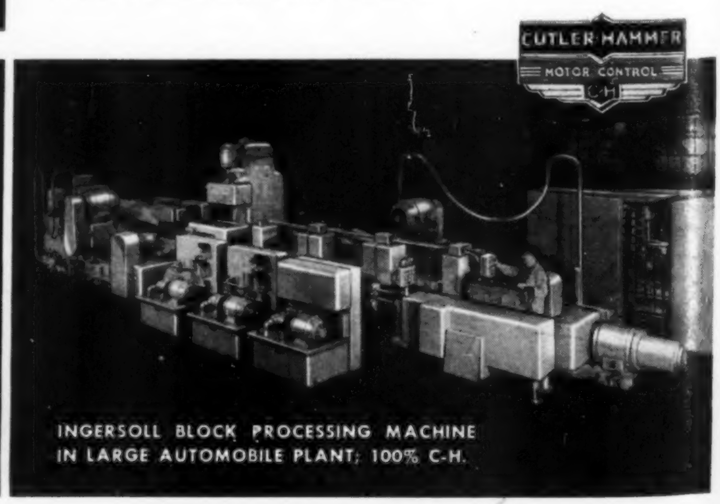

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MACHINE DESIGN

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

Vol. 23—No. 2 **February, 1951**

DESIGN FOR PRODUCTION • STYLING • MATERIALS SPECIFICATION • DESIGN ANALYSIS • MACHINE COMPONENTS • ENGINEERING MANAGEMENT

Over the Board

Russians

Conspicuous at meetings of such organizations as the Society of Automotive Engineers during World War II were the distinctive uniforms of Russian technical officers here as "gallant allies" to learn our engineering and production know-how. It goes without saying that no Russian uniforms were in evidence at the annual SAE meeting in Detroit last month. Instead, a former enemy—once a design engineer for Messerschmidt in Nazi Germany—told a fascinating tale of how engineering development suffered at the hands of ignorant politicians possessing the absolute power of totalitarian dictatorship. While his talk held many lessons for our country in pointing out the dangers of too tight government controls, it was reassuring in the light of our knowledge that engineers under Communism live in even greater terror of the consequences of making mistakes than those under Hitler.

Incidentally, you may be interested to know that copies of MACHINE DESIGN are no longer being delivered behind the Iron Curtain, the State Department having finally given our circulation department permission to cut off the sale of copies formerly going to Russia and its satellites.

This Month's Cover

Working with Ken Engle of Public Relations at Glenn Martin in polishing up the final arrangements for John Van Hamersveld's article, Page 108, we naturally were intrigued by the possibility of an accompanying cover. As a result Ken came up with the matchless job you see this month. We'll be hard pressed in the future to beat this dramatic portrayal of the ultimate in machine design. While practically all the details dealing with the design and performance of these Martin XB-51 ground support light bombers are held under strict military security regulations, we are permitted to state that design cost control efforts under the plan outlined in Van's article will effect minimum cost in the production of the various components of these planes.

Engineering Management

If you have been reading MACHINE DESIGN's recent articles on various phases of engineering management you'll know that they are chock full of ideas and principles of lasting value. So many of you have asked for extra copies that we have reprinted fourteen of the articles in a handy pocket-sized book—just the thing to help you capitalize on odd moments of seemingly wasted time spent waiting for overdue planes or trains. First four chapters comprise the recent series of articles by Randolph Chaffee on "Engineering Management—Its Job." The remaining chapters cover such subjects as predesign research, engineering reports and manuals, engineering record and drawing change systems, and engineering personnel selection, development and morale. Published under the title *Engineering Management,* the book is priced at one dollar.

So encouraging has been your response to engineering management articles that we are continuing to present such articles at frequent intervals. John Van Hamersveld's article on Cost Control Engineering, Page 108, and Robert T. Casey's on Patents, Page 125, in the current issue are notable examples. Others are in the works, including another series by Randolph Chaffee, this time on Evaluating Engineering Personnel.

All Thumbs?

Did you ever stop to think how we would do our figuring if we had no fingers—only a pair of thumbs? For one thing the decimal system would probaly never have gotten started, and because we would count only on our thumbs the cycle of numbering would be two instead of ten. The question is not purely academic, because a counting system which employs only two digits is becoming increasingly important. It is of course used in digital computing machines or "giant brains" which depend on such mechanisms as switches and relays for their operation. You see, with only two kinds of numbers, odd and even, the choices which confront the mechanical "brain" (which actually isn't so smart, only fast) are simple—of the type open or closed, which can be translated into such questions as odd or even, yes or no, black or white, innocent or guilty, bourbon or scotch.

Any decimal number can be expressed in terms of so-called binary numbers which are characterized simply as odd or even and can be added, subtracted, multiplied, or divided by a digital computing machine. A novel system of converting from one system to the other is offered by Ed Varnum in his article which begins on Page 121. His double, dabble, rouble, rabble processes are a fascinating mental exercise; try converting your own age to a binary number! We predict that the system will never be popular with the ladies because it makes 29 look like 11101.

ITEMIZED INDEX

Classified for convenience when studying specific design problems

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries generally.

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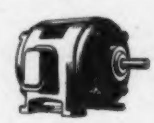

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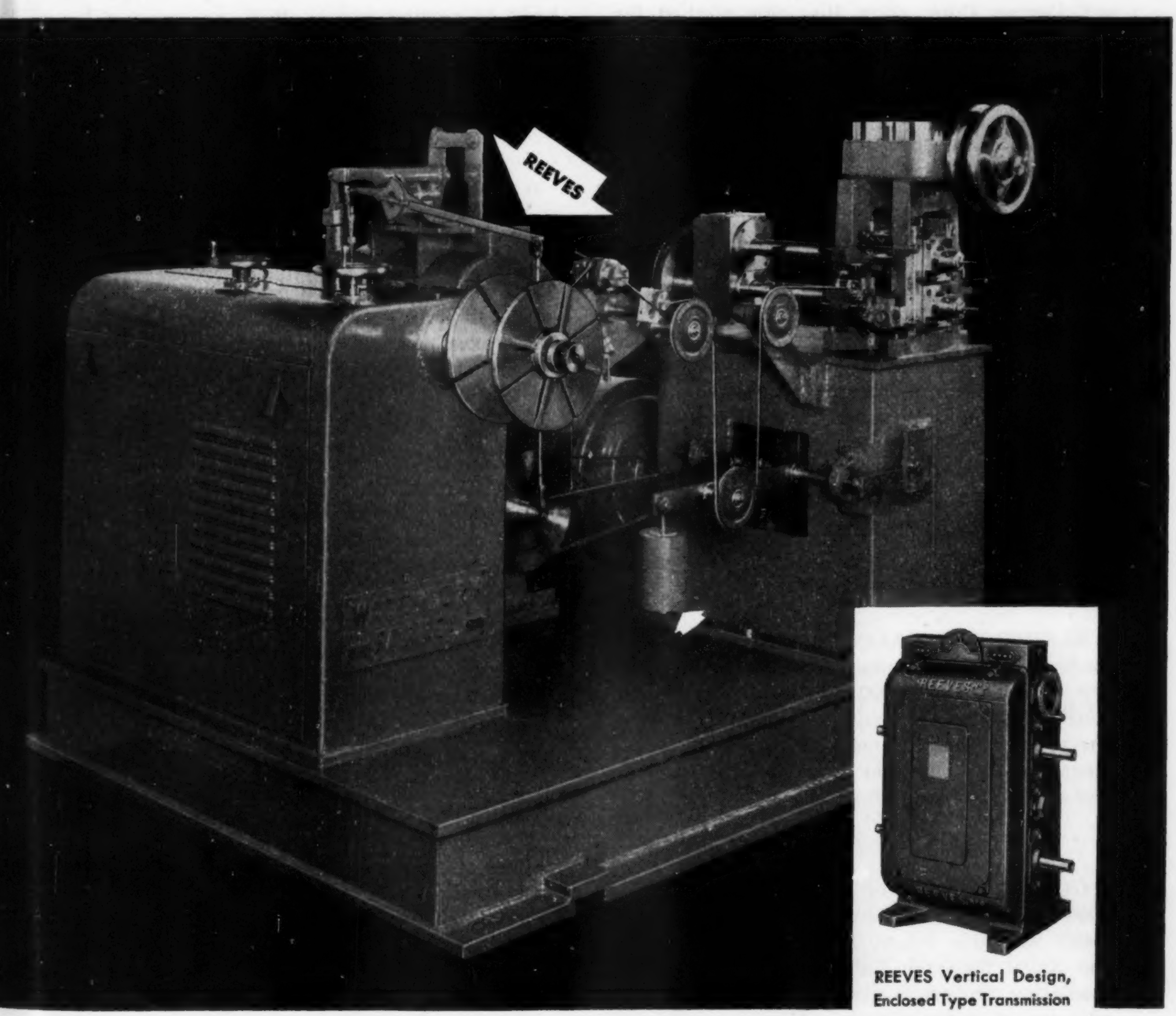


REEVES Vertical Design, Enclosed Type Transmission

A wide range of wire sizes up to .06" diameter can be handled at speeds up to 1000 fpm on this REEVES-equipped Waterbury-Farrell wire flattening mill. Tension of wire is controlled automatically by a REEVES hydraulically controlled vertical type transmission. Proper tension for each size and kind of wire is pre-set by weights on floating roll. The floating roll actuates the highly sensitive REEVES hydraulic control to reduce winding speed and maintain constant tension as spool builds up. By adding or removing weights, the machine can be immediately and conveniently operated on other sizes and kinds of wire.

TOPICS

SERIES-ARC WELDING, using two or more converging welding rods connected electrically in series, leaves the base-plate material independent of the circuit and thus reduces heat penetration. Developments by Union Carbide and Carbon Corp. show that this method for giving minimum penetration is of particular value in cladding operations where dilution of the weld by the base metal is undesirable. Also, economy is gained since most of the electrical energy is consumed in melting the welding rods—little in fusing the base material.

CONSTANT LINEAR SPEED of veneer sheet peeled from logs is provided by a lathe drive installed at the Puget Sound Plywood Co. Designed by General Electric, the drive consists essentially of a 100-hp d-c driving motor and a 100-kw generator with amplidyne excitation for both generator and motor fields. Combination of motor-mounted tachometer-generator and knife-operated rheostat produces a voltage which is proportional to veneer-sheet speed and is used with the amplidyne circuit to hold sheet speed constant.

ELECTRONIC CALCULATOR of the most intricate type yet produced by IBM has a memory capacity of 400,000 digits. By paper and pencil, 1500 years would be required to solve one problem that the machine completed in 2½ months—after one year was spent in planning and setting up the problem.

GLASS-FIBER filter paper, claimed to be 5000 times more effective than present commercially available filters, has been developed by the Naval Research Laboratory. Its electrical insulating properties also make the paper suitable for other applications. Used in condensers for electronic equipment, for example, the paper will permit a reduction in condenser size because it is thinner and more heat-resistant than insulating papers now available.

ULTRASONICS have been adapted to the measurement of the speed of water in ducts, according to a report by W. B. Hess, S. K. Waldorf and R. C. Swengel before a recent AIEE meeting. Transducers used for measurement are placed at opposite walls of the duct, displaced some distance along the principal axis of flow. Velocity is calculated from the measured phase angle between the transmitted ultrasonic signal and that received after passing through the body of moving water. With an error of less than 2 per cent, the procedure offers simplification in determination of turbine-discharge velocity in hydroelectric plants without interruption of normal operation.

METAL-POWDER jet-engine blades heat treated to 100,000 psi ultimate strength are being produced by Thompson Products Inc. The alloy consists of pressed iron powder infiltrated with a liquid copper alloy at 1900 F. The blades have excellent damping capacity, a property which extends their vibration-fatigue life.

ANAEROBIC PERMAFIL is the name given a new General Electric material that remains liquid as long as a stream of air bubbles through it but hardens when away from air. The compound hardens fully by chemical change (polymerization) instead of, like paint, through evaporation. Not yet commercially available, the material is expected to find applications requiring penetration and complete drying of a liquid seal in minute cracks and pores, such as in sealing threaded joints or porous castings.

NEOPRENE COATINGS as thin as 0.010 to 0.012-inch are effective in reducing the eroding action of rain on plastic laminate radomes of high-speed planes. Similar protection is also being considered for the pure aluminum cladding on leading edges of planes. On a recent test plane flying for 20 hours at 400 mph, most of the cladding was rain blasted away.

HIGH-FREQUENCY INDUCTION heating has been adapted to the baking of cork composition in an automatic and continuous-process installation developed by Armstrong Cork Co. Baking cycle has been reduced to a matter of minutes, in contrast to six to twelve hours required by the previous steam-heat process. With all auxiliary processes synchronized with the induction baking, the total operation is guided by 500 relay contacts and 150 precision switches.

MACHINE DESIGN
A PENTON PUBLICATION

Incentives in Design

THIS is frankly a plea to management to take fresh stock of a situation that is not always too obvious to those at the top: the effects of present patent assignment policies. Elsewhere in this issue Robert T. Casey urges honest and intelligent handling of ideas developed by employees and suggests a practical setup that will facilitate such handling.

It goes without saying that reputable machinery manufacturers are completely honest in abiding by the terms of agreements with engineers regarding patent assignment. But a truly intelligent approach toward submitted ideas must recognize the importance of equitable distribution of the rewards of successful invention.

The fair-minded engineer admits the justice of the purely nominal fee usually paid for assignment of a patent by an employee to his company. He is well aware of the cost of the facilities which helped him develop the invention on the job, and he knows what it costs to translate a paper design into a successful machine. These heavy expenses and the attendant risks are borne by the company while the engineer-employee enjoys peace of mind and a steady income.

It is when the machine becomes a financial success and he sees the profits which his ideas made possible being channeled elsewhere that the engineer begins to lose his contentment. This is the point at which enlightened management can step in with a policy of just distribution of rewards. For the designer this would mean payment of some sort of royalty, bonus, commission on sales, or percentage of profits resulting from the sale of the machine. Naturally, the percentage decided upon would be a function of the relative importance of the invention or patented idea, but in any event a clear understanding of the basis of payment should be established in the designer's mind.

Such a policy would have far-reaching effects in improving morale by providing an incentive that would bring out design talent to the fullest possible extent. It would also bring to light a continuing flow of new and novel ideas, the possibilities of which—in terms of revived enterprise, expanded business and better living—are limitless.

Colin Carmichael

EDITOR

Cost Control Engineering

. . . stepping stone to better design proficiency

By John Van Hamersveld
Supervisor
Design Cost Control
Glenn L. Martin Co.
Baltimore, Md.

Part 1—Organization and Functions

BECAUSE the designs released by engineering set the cost pattern for any product, the key to low cost production is the engineering division. To promote this responsibility, The Glenn L. Martin Company has established a consulting group of design cost control engineers to cope with the overall effects of designs with regard to the manufacturing divisions. This organized function is a necessary requirement of modern engineering management. It is evident that a number of the most reputable domestic industries subscribe to this new concept by the steps they have taken recently to comply with this need for design-manufacturing co-ordination.

From a designer's point of view, the consulting services of such a group enable him to design superior products and thus increase his stature in the engineering department. These efforts can also act as an incentive to creative engineering in the form of more efficient functional designs predicated on the availability of manufacturing facilities. From the company's point of view, such a group promotes a progressive cost-conscious attitude throughout the engineering organization. Finally, this attitude is reflected in co-ordinating the complete aspects of machine design.

DESIGN FOR PRODUCTION: The ultimate solution to any specific design problem generally necessitates the development of alternate designs, each of which must satisfy the design conditions of functional capacity, structural integrity, material availability, manufacturing techniques, sales appeal, and customer specifications. Also involved is a realization of many other specific factors, depending upon the type of end product. In order to develop the best design to meet these conditions, it is desirable that the engineer be familiar with all possible ramifications of the design elements mentioned. Adequately meeting the majority of the design conditions will depend upon the

comprehensiveness of the engineer's knowledge of design and manufacturing producibility. To comprehend the principles of and distinction between design and manufacturing producibility, it will be necessary to establish a basic understanding of the two terms.

Design Producibility can be defined as "the inherent design characteristics of a product which render it capable of rapid, efficient and expansible production with reference to the availability of manufacturing facilities." It implies that all details, subassemblies, and assemblies have been production-designed so that they can be produced with the maximum utilization of the lowest possible level of skills, and a minimum of effort and cost.

Manufacturing Producibility may be defined as "the ability of manufacturing to effectively obtain maximum production in a specific time span and be capable of maintaining an accelerated production rate". This implies that a thorough familiarity with the latest fabricating methods and an efficiently planned breakdown of a production process is required to assure maximum utilization of all available facilities.

DESIGN COMPATIBILITY: Engineering design following these concepts requires planned co-ordination in development, design producibility being the initial stage capable of expanding into a design with inherent manufacturing producibility. To what degree the designer can balance these constituents to reach proper decisions is revealed in a typical design problem of a main engine support nacelle frame as shown in *Fig.* 1 and the discussion which follows.

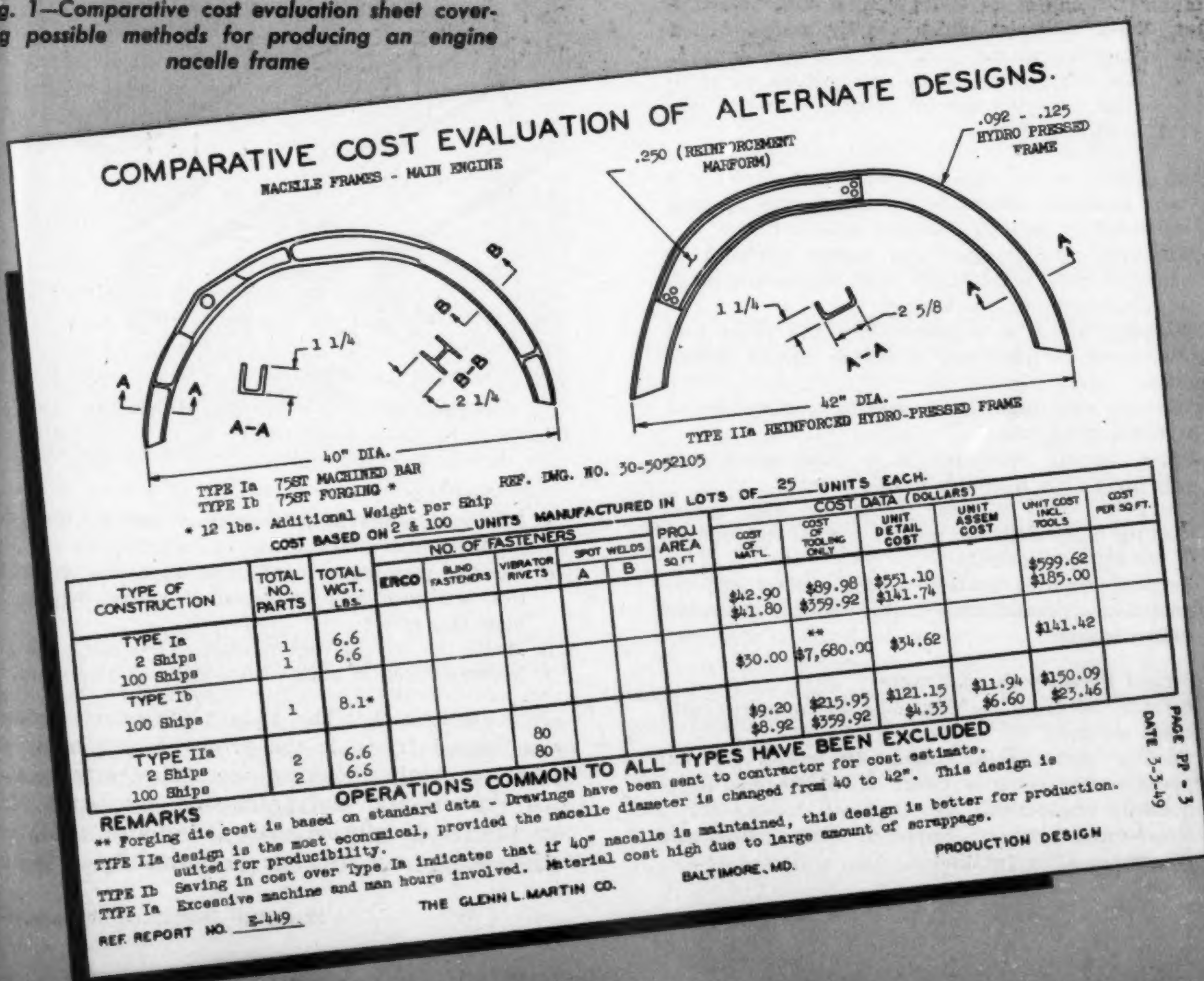
Design and Structural Requirements: To ensure a high-performance airplane, it was suggested that the size of the engine nacelle be predicated on a 40-inch outside diameter. As a result of this basic premise, an investigation of bar stock, forging and sheet-metal versions of this frame was pursued. Structural bending is the chief effect in this design and would eliminate a 40-inch diameter sheet-metal frame version. The greater the channel depth, the more effective is the structural design achieved. Also important are the lighter weight and more economical design attained.

Modification Permits Sheet-Metal Design

By increasing the diameter of the upper half of the nacelle frame to 42-inch diameter, the sheet-metal version would be feasible for all conditions. Further alternate types of nacelle construction and suspension methods were investigated, based on the 40-inch diameter. However, the survey revealed weight increases, expansion problems, and load distribution complications.

This structural check indicated that it was advisable to evaluate the various production problems that might occur between the 42-inch diameter reinforced press-formed design versus that of the 40-inch diameter bar stock and forging.

Production Problems: A study of the problems in



COMPARATIVE COST EVALUATION OF ALTERNATE DESIGNS.

NACELLE FRAMES - MAIN ENGINE

TYPE Ia 75ST MACHINED BAR
TYPE Ib 75ST FORGING *
* 12 lbs. Additional Weight per Ship

REF. DWG. NO. 30-5052105

COST BASED ON 2 & 100 UNITS MANUFACTURED IN LOTS OF 25 UNITS EACH.

TYPE OF CONSTRUCTION	TOTAL NO. PARTS	TOTAL WGT. LBS.	NO. OF FASTENERS: ERCO	BLIND FASTENERS	VIBRATOR RIVETS	SPOT WELDS: A	B	PROJ. AREA SQ FT	COST DATA (DOLLARS): COST OF MAT'L.	COST OF TOOLING ONLY	UNIT DETAIL COST	UNIT ASSEM COST	UNIT COST INCL. TOOLS	COST PER SQ FT.
TYPE Ia 2 Ships 100 Ships	1 1	6.6 6.6							\$42.90 \$41.80	\$89.98 \$359.92	\$551.10 \$141.74		\$599.62 \$185.00	
TYPE Ib 100 Ships	1	8.1*							\$30.00	** \$7,680.00	\$34.62		\$141.42	
TYPE IIa 2 Ships 100 Ships	2 2	6.6 6.6			80 80				\$9.20 \$8.92	\$215.95 \$359.92	\$121.15 \$4.33	\$11.94 \$6.60	\$150.09 \$23.46	

OPERATIONS COMMON TO ALL TYPES HAVE BEEN EXCLUDED

REMARKS
** Forging die cost is based on standard data - Drawings have been sent to contractor for cost estimate.
TYPE IIa design is the most economical, provided the nacelle diameter is changed from 40 to 42". This design is suited for producibility.
TYPE Ib Saving in cost over Type Ia indicates that if 40" nacelle is maintained, this design is better for production.
TYPE Ia Excessive machine and man hours involved. Material cost high due to large amount of scrappage.

PAGE PP - 3
DATE 3-3-49

PRODUCTION DESIGN
THE GLENN L. MARTIN CO. BALTIMORE, MD.
REF. REPORT NO. E-449

Fig. 1—Comparative cost evaluation sheet covering possible methods for producing an engine nacelle frame

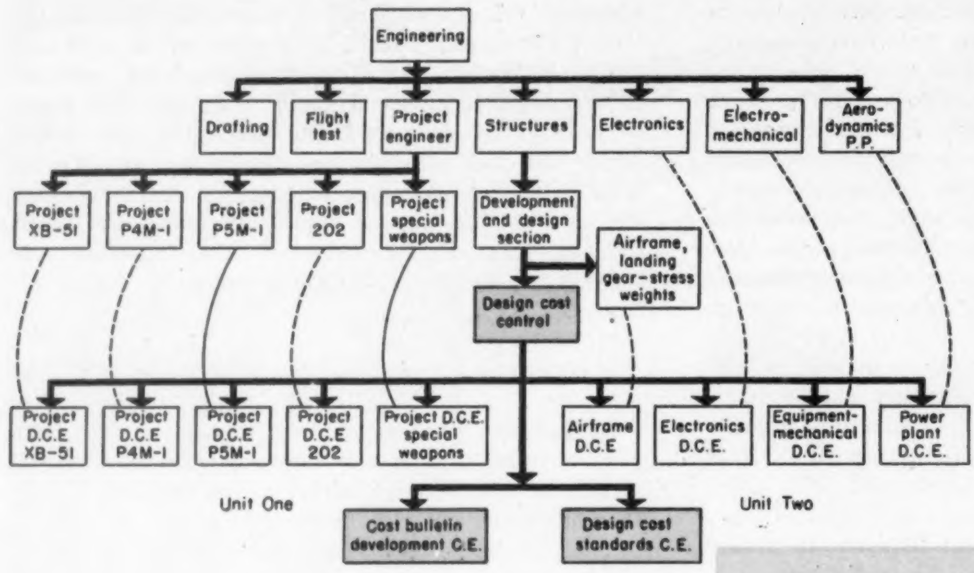
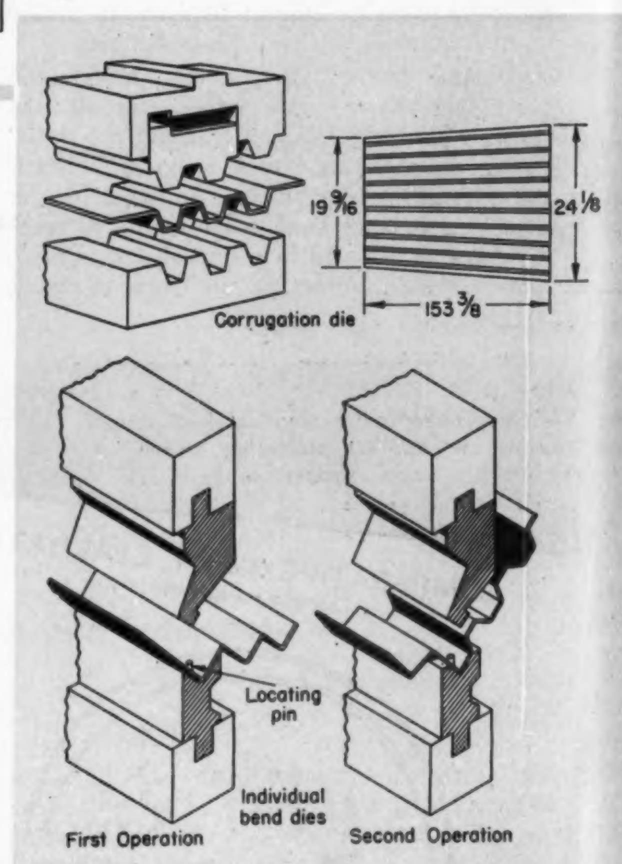


Fig. 2 — Left — General organization chart for engineering including a cost control design group

Fig. 3—Below — Two methods of producing a corrugated wing blanket studied for cost factors



regard to design and manufacturing producibility developed the following data:

Bar Stock

1. DoAll sawed to shape from plate stock—excessive material waste—note high material cost in *Fig.* 1
2. A multitude of tedious end milling cuts and layout checks required
3. Major difficulties in straightening after machining 75S-T material which readily warps during machining operations
4. Part size difficult to handle and position on vertical miller requiring special indexing tools to machine contour surfaces.

Forging

1. Only available alternate for production quantities based on 40-inch diameter nacelle frame
2. Machining still required on faying surfaces. If weight is to be maintained, draft angles and pockets will necessitate machining
3. Warpage again a problem since the outer contour must be machined to match nacelle fairing lines
4. Die cost very high due to size of forging, *Fig.* 1, at $7680 per frame
5. Press forging technique is a requirement with only one source available in this country
6. There are eight of these frames per ship, necessitating eight separate dies at a total expenditure of $61,440 per contract
7. Forging requires outside vendor control and negotiations—producibility limited to one manufacturing source.

Reinforced Press-Formed Frame

1. Economical from material cost as compared with other methods
2. Tooling cost nominal—Masonite blocks for experimental quantities—steel draw die for high-quantity production
3. Press-formed frame simple to manufacture and straighten after forming
4. Marform reinforcement channel can be held to accurate dimensions
5. Nesting may cause some manufacturing difficulties, but good shop co-ordinated control will minimize this effect
6. Meets the weight requirement of bar-stock design
7. Manufactured in plant under controlled conditions.

It is obvious that the 42-inch diameter reinforced press-formed frame is the proper selection for this design to obtain the most economical structure for both experimental and production quantities. This comparative design-cost analysis initiated a reinvestigation of the aerodynamic performance of the air-

JOHN VAN HAMERSVELD, through what might be called unique circumstances, has had the opportunity to focus his attention virtually one-hundred per cent on the relationship of manufacturing costs and design. Under his keen eye has developed at the Glenn L. Martin plant an outstanding permanent program of design cost control. In developing this unusually successful engineering organizational setup, his experience in production, cost accounting and design has been instrumental in producing dollars-and-cents results. A graduate of Case Institute of Technology in mechanical engineering, he has carried on subsequent work at Johns Hopkins and the University of Maryland. His experience includes eleven years of service at Glenn L. Martin Co. and three years with the Warner & Swasey Co. of Cleveland. An ardent promoter of better design from a cost standpoint, Mr. Van Hamersveld has written extensively and talked before many engineering and management groups on the subject.

plane to determine the actual effects in per cent increase of form drag, decrease of attack radius, increase of fuel consumption, high and cruise speed variations. This recheck indicated that these percentage changes were not too great and through a compromise it would be possible to accept the performance changes to facilitate the producible aspects of the nacelle configuration.

A yardstick for measuring the relationship of performance to producibility and cost would be valuable, but this is one of the most difficult problems to solve. At present, these factors must be weighed as shown by this analysis; they require management decision to establish the compromise.

The engineer, besides knowing the principles of design and manufacturing producibility, should also acquire a familiarity with the various factors that contribute to the manufacturing costs in order that he may be able to select not only the most economical method but also the most economical use of the method selected. It is inconceivable, due to the rapid advancement in design and in the improved and highly operationalized forming and machining facilities, that a designer will have acquired all the know-how necessary to fulfill the above requirements.

In addition, the ever-increasing critical engineering time span does not always permit the designer to devote his efforts to studies and investigations which may be required to evaluate various alternate designs. It is essential, however, that efficient producibility of the design be assured before its release for manufacturing.

Design Cost Control Engineering Management: Industry is now placing greater emphasis upon the requirement that producibility be reflected in their products. To assist the designer in pursuing these concepts and low cost, the necessary investigations and comparative analyses are responsibilities assigned to the design cost control unit.

Organization And Function: The organizational diagram, *Fig.* 2, illustrates the functional relationship of the design cost control unit with regard to the engineering division. The group functions in a consulting capacity through the development and design section, which in turn reports to the chief structural engineer. The structures department is mainly responsible for functional design, stress and weight analyses, vibration, material specifications, design and manufacturing producibility.

Under this organizational system, design cost control can function as an unbiased group in making a design-cost decision, but it cannot make the final design decision without the approval of the structural engineer. His responsibilities involve the structural integrity and quality of the product. A balanced comparison between the most economical design and the most efficient overall functional design is a necessary requirement to produce a dependable product at minimum cost.

Two Categories of Functions

As shown by the diagram, the cost control group is divided into two categories of duties and functions. The first unit, composed of project design cost control engineers, is directly located in the project section. Its primary control is the liaison function of providing "on the spot" design-cost information. The personnel attached to this unit are specialists in their respective fields, collaborating with the design engineers to achieve economical design releases for manufacturing. The design study, as shown in *Fig.* 1 is a typical example of this collaborative effort to solve the problem of the nacelle frame structure.

The second unit consists of development design cost control engineers responsible for providing design-cost information to the design engineers in the basic design sections, and also for the development of standards such as cost bulletins, standard data, dollar cost conversion factors and development analyses. This unit furnishes the project cost engineers with supplemental data and assists in the preparation of

comparative analyses requiring lengthy investigations.

Group concentration is thus established on design problems that result in many suggestions to achieve economical solutions. Also, detail duties of the project cost control engineer are minimized so that his daily contacts with design personnel can be carried out with maximum efficiency. The personnel of each unit are well versed in the fields of manufacturing processes, cost accounting, production design techniques, and industrial engineering standard data.

Responsibilities and Functions: The general responsibilities of the design cost control engineer are to maintain design economy throughout the layout and detail stage of product design. In order to fulfill this obligation, each cost engineer is required to initiate, change and evaluate all types of design proposals. They are directly and indirectly responsible for maintaining: (1) Simplicity of configuration; (2) ease of fabrication; (3) minimum number of parts; (4) ease of assembly; (5) efficient production breakdown; (6) standard components and accessories. These are the fundamental requirements of design and manufacturing producibility. In general, the operational functions of cost control engineers are:

1. Maintain a personal touch by daily routine checks of design layouts to set the stage for design economies. This consistent personal relationship with design personnel is the key to a successful operating cost control organization
2. Study and evaluate design layouts to determine whether a cost investigation is necessary and justifies the expense of making an analysis
3. Provide cost development group with all necessary information pertaining to cost studies that can be developed into design histories for bulletin insertion
4. Execute cost reports to maintain the library of design cost information
5. Maintain an up-to-date knowledge of the latest practices in production, tooling, manufacturing, accounting, standard data, and design philosophies.

The design functions of cost control engineers are:

1. Review designs for detail economies such as comparative material costs, liberal tolerances, minimum machining, ease of forming, ease of assembly, use of standard parts, correct fasteners, availability of material, availability of shop equipment, limitations of shop equipment, correct processes, etc.
2. Investigate design changes to keep scrap loss and manufacturing costs to a minimum
3. Maintain a constant surveillance of possible production "bottle necks" caused by insufficient design study
4. Maintain a project cost savings schedule report to inform management of the cost reduction savings.

Qualifications: Important to consider in a program such as this, the qualification requirements for a design cost control engineer are:

1. Fundamental knowledge of engineering principles with the ability to recommend design improvements and to understand the principles of structural design that may be required to bring about such improvements or recommendations
2. Specialist in the applications of production design principles and the solutions of producibility problems
3. Excellent judgment in the use of standard data per operation and labor cost factors to cope with the many variables in developing cost analyses
4. Ability to understand the techniques of cost accounting in the use of wage rates, burden charges and cost procedures
5. Thorough knowledge of the operations of all types of machines and tools required in manufacturing
6. Ability to compile clear readable reports on recommendation of cost developments
7. Mathematical capability to develop cost factors, quantity-cost curves, and statistical records of design costs
8. Most important, excellent aptitude for presenting visually the development of cost breakdowns and design simplification principles.

Men with all these qualifications are difficult to obtain. However, a design cost control group can be successful with men who have fundamental engineering knowledge and sufficient practical shop experience. With these two basic requirements, men can be trained in the fields of industrial engineering, cost accounting and report writing. Experience has shown that liaison engineers make competent design cost control personnel, since through their experiences they have developed a perspective relationship between manufacturing and engineering activities.

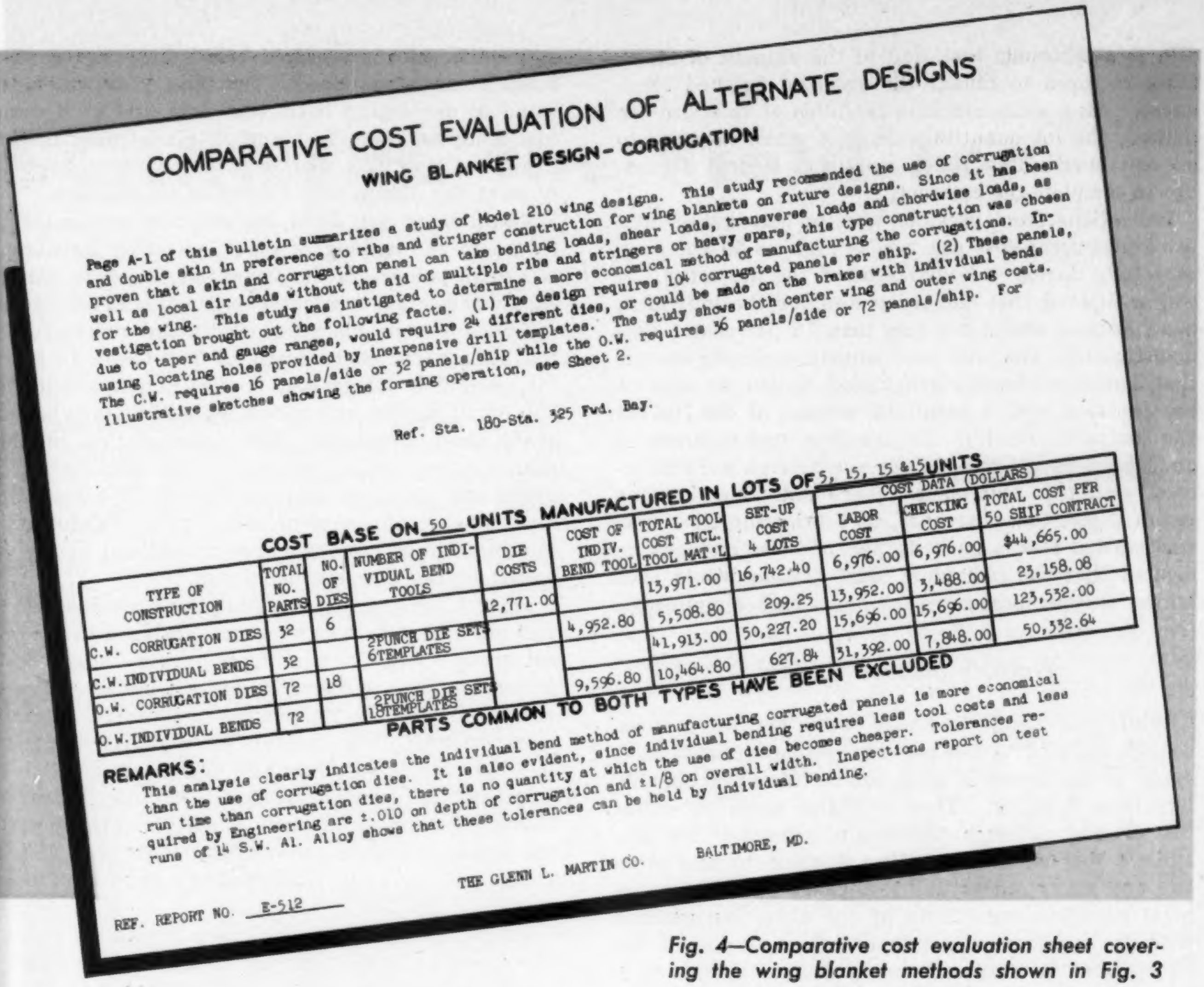
Operating Policies: Operational policies of the cost engineer are of paramount importance since he performs in a consulting capacity throughout the engineering organization. The success of this service depends upon his ability to:

1. Co-operate and co-ordinate his efforts with those of the project and group engineers in the design sections
2. Convince others that cost ideas, attitudes, designs and philosophies are basically sound and essential to economic manufacturing procedure
3. Avoid dominance, argument and forcefulness in presenting cost problems. Use the diplomatic approach
4. Maintain the respect and integrity of the plant organization in making design cost decisions.

Co-ordinating Efforts: Co-ordination of departmental costs in solving a design problem is one of the cost engineer's most significant duties since his views emphasize the overall expenditures rather than each individual department's costs. As a result of these investigations, each department's costs are knitted together into the final design-cost decision.

By cost studies the various cost increases and changes can be viewed with the proper recommendations as to what part of the design or manufacturing condition can be corrected to obtain an overall cost reduction. These co-ordinating procedures will minimize the effects of departments shifting cost from one to another. Cost shifting often produces a feeling that a department has independently reduced its own costs and, therefore, has reduced the overall cost of fabricating the product. This practice can only result in misrepresentation of the true cost of the product.

An example of these co-ordinating efforts is shown



COMPARATIVE COST EVALUATION OF ALTERNATE DESIGNS

WING BLANKET DESIGN - CORRUGATION

Page A-1 of this bulletin summarizes a study of Model 210 wing designs. This study recommended the use of corrugation and double skin in preference to ribs and stringer construction for wing blankets on future designs. Since it has been proven that a skin and corrugation panel can take bending loads, shear loads, transverse loads and chordwise loads, as well as local air loads without the aid of multiple ribs and stringers or heavy spars, this type construction was chosen for the wing. This study was instigated to determine a more economical method of manufacturing the corrugations. Investigation brought out the following facts. (1) The design requires 104 corrugated panels per ship. (2) These panels, due to taper and gauge ranges, would require 24 different dies, or could be made on the brakes with individual bends using locating holes provided by inexpensive drill templates. The study shows both center wing and outer wing costs. The C.W. requires 16 panels/side or 32 panels/ship while the O.W. requires 36 panels/side or 72 panels/ship. For illustrative sketches showing the forming operation, see Sheet 2.

Ref. Sta. 180-Sta. 325 Fwd. Bay.

COST BASE ON 50 UNITS MANUFACTURED IN LOTS OF 5, 15, 15 & 15 UNITS

TYPE OF CONSTRUCTION	TOTAL NO. PARTS	NO. OF DIES	NUMBER OF INDIVIDUAL BEND TOOLS	DIE COSTS	COST OF INDIV. BEND TOOL	TOTAL TOOL COST INCL. TOOL MAT'L	SET-UP COST 4 LOTS	COST DATA (DOLLARS) LABOR COST	CHECKING COST	TOTAL COST PER 50 SHIP CONTRACT
C.W. CORRUGATION DIES	32	6		12,771.00		13,971.00	16,742.40	6,976.00	6,976.00	$44,665.00
C.W. INDIVIDUAL BENDS	32		2 PUNCH DIE SETS 6 TEMPLATES		4,952.80	5,508.80	209.25	13,952.00	3,488.00	23,158.08
O.W. CORRUGATION DIES	72	18				41,913.00	50,227.20	15,696.00	15,696.00	123,532.00
O.W. INDIVIDUAL BENDS	72		2 PUNCH DIE SETS 18 TEMPLATES		9,596.80	10,464.80	627.84	31,392.00	7,848.00	50,332.64

PARTS COMMON TO BOTH TYPES HAVE BEEN EXCLUDED

REMARKS:

This analysis clearly indicates the individual bend method of manufacturing corrugated panels is more economical than the use of corrugation dies. It is also evident, since individual bending requires less tool costs and less run time than corrugation dies, there is no quantity at which the use of dies becomes cheaper. Tolerances required by Engineering are ±.010 on depth of corrugation and ±1/8 on overall width. Inspections report on test runs of 14 S.W. Al. Alloy shows that these tolerances can be held by individual bending.

THE GLENN L. MARTIN CO. BALTIMORE, MD.

REF. REPORT NO. E-512

Fig. 4—Comparative cost evaluation sheet covering the wing blanket methods shown in Fig. 3

in the design problem of the wing blanket corrugation, *Fig.* 3. This represents the co-ordinated endeavors of the project design cost control engineer with tool design, manufacturing and engineering. This investigation brought out the following facts:

1. The wing design required 104 corrugated panels per plane
2. These panels, due to taper and gage ranges, would require 24 different corrugation dies
3. Corrugation could be made with individual bends on a brake by using locating holes provided by a relatively inexpensive drilled template
4. Opinion was divided as to the additional run time required to make individual bends over multiple bend dies
5. Opinion was divided as to whether tolerances could be held with or without dies.

A preliminary cost analysis indicated that corrugations made by individual bends would be cheaper than if made by dies on a 50-ship contract, providing tolerances satisfactory to engineering could be held and the run time was not excessive. Therefore, tests were ordered to determine (1) what tolerances could be held, and (2) how much run time was required. The following shows the progress and results of these tests, plus a cost summary upon which a decision was reached.

A loft template showing a typical outer wing corrugated panel was selected, a drill template ordered and representatives from the manufacturing research group and the shop were assigned to run the tests. The first four pieces run were not in tolerance primarily because of machinery failure. The fifth piece was in tolerance, and four additional pieces were drilled to be run on the same brake setting. Tolerances required by engineering were ±0.010-inch on depth of corrugation and ±⅛-inch on overall width. Inspection's report showed that these tolerances could be held by individual bending. Personnel of the methods and standards group took time studies which revealed run times far below previous estimates. These gratifying results were largely due to new procedures suggested by the shop. By bending every other bend as a first operation, the panel acquires stiffness which prevents die slippage in the center, thus producing a straighter, more uniform corrugation free of camber.

Evaluation Reveals True Factors

The comparative cost evaluation as prepared, *Fig.* 4, indicates the cost breakdown between the two methods of fabricating the wing panels. Combined tooling, setup costs and checking costs were the main factors that effected the cost savings of the individual bend method. In the corrugation die method previous experience has shown that the setup of these large

dies is a laborious task due to the amount of shimming required to obtain the specified finished tolerances. Also, since machine facilities of this size are limited, the lot quantities are held small in order to prevent overloading which results in several die setups to complete the contract.

Indications from previous uses of corrugation dies were that scrap loss can run as high as 50 per cent, especially during the check-out of the die setup. It was estimated that the scrap loss for the individual bend method would run less than 15 per cent. This investigation, test and cost summary clearly dictate that individual bend corrugations should be used on the contract with a resultant savings of $95,706 for the contract quantity. Engineering, tool engineering and detail manufacturing representatives were in accord with this statement. Since individual bending requires less tool cost and less fabricating time than corrugation dies, a quantity plot of these methods indicated that the individual bend process would even be the cheaper procedure for much higher quantities.

Problem Solution Typical

While the tests conducted were not on a large enough scale to be 100 per cent conclusive, they have given an indication of what can or cannot be done by individual bending. They will also serve to adjust the divided opinions previously expressed for and against the use of dies. The solution to this problem and many others like it depends upon the maximum co-ordinating efforts of the plant organization with the minimum of red tape or paper work. These efforts aid the cost engineer in decreasing the preparation time of analyses for prompt decision and directly reduce drafting schedule delays.

Establishment of a Design Cost Control Unit: To initiate a design cost control group in a plant organization requires co-operation between management, manufacturing and engineering to enable the personnel of this group to move freely throughout the organization to obtain the necessary data in solving the parent problem. They must also gain the respect of these divisions so that the decisions that are made in collaboration with engineering personnel will be effectively carried out through the plant organization to obtain economical product development.

The size of this group depends entirely on how effective a control management may require. The degree of industrial competition can be a governing factor as to the amount of control that is necessary to obtain the desired low cost product. In per cent of design personnel, the size of the group may be from 1 to 5 per cent. Since it costs money to operate the group, the size can also be affected by the type of trained personnel acquired to do the job. Too large a group can become overbearing and lose efficiency of operation. By maintaining a high type of qualified personnel who can work independently in developing analyses, a more capable organization is achieved with the minimum of interference. This is especially true for project design cost control engineers.

It is estimated that once a group is established and depending upon the complexity of the product, at least a year is required before any degree of efficiency can be obtained. This first year will be devoted to developing basic cost data and each design cost study will require a complete analysis. In turn, these cost analyses written in report form essentially start the design cost library of information.

This library will form the stepping stones for the future to the making of quick, effective decisions as to design policies in the layout stage. Also, this design information can later become bulletin data to establish design histories for future reference. In the design cost control unit of The Glenn L. Martin Co., over 500 design cost studies and approximately 150 detail studies of various types of fittings have already been developed. The accumulation of these data has appreciably stepped up the efficiency of the group and provided valuable records of design progress. The development of this library of information is a continuous process and is maintained by the personnel of the development group.

Budget charges for the group are divided into direct and indirect. The personnel assigned to the project group operate under direct project budget, which is a percentage of the total project budget. The development unit of the design cost control organization performs under indirect or overhead charges as they are developing data and design information not only for the present contracts, but for future contracts. In some companies it may be wise to set up the entire group as an overhead function. This depends entirely upon management's method of operation.

In either case the entire group proves its value by the amount of yearly savings it can achieve. For example, a previous yearly check indicated the following statistical summarization:

Total Potential Savings	$861,701 or $123,100 per man
Actual Savings incorporated	$312,244 or $44,606 per man
Number of written report studies	82
Average per cent cost reduction under comparative design	47.46%

These statistical figures for a year's work certainly indicate the effectiveness of a design cost control organization in modern engineering management. Part 2 of this article, Cost and Design Data, will appear in the March issue of Machine Design.

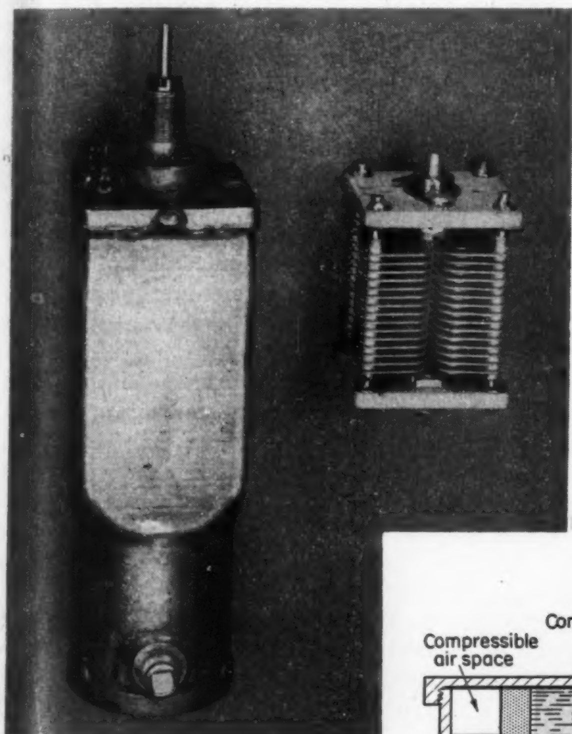
Television Aids Industrial Control

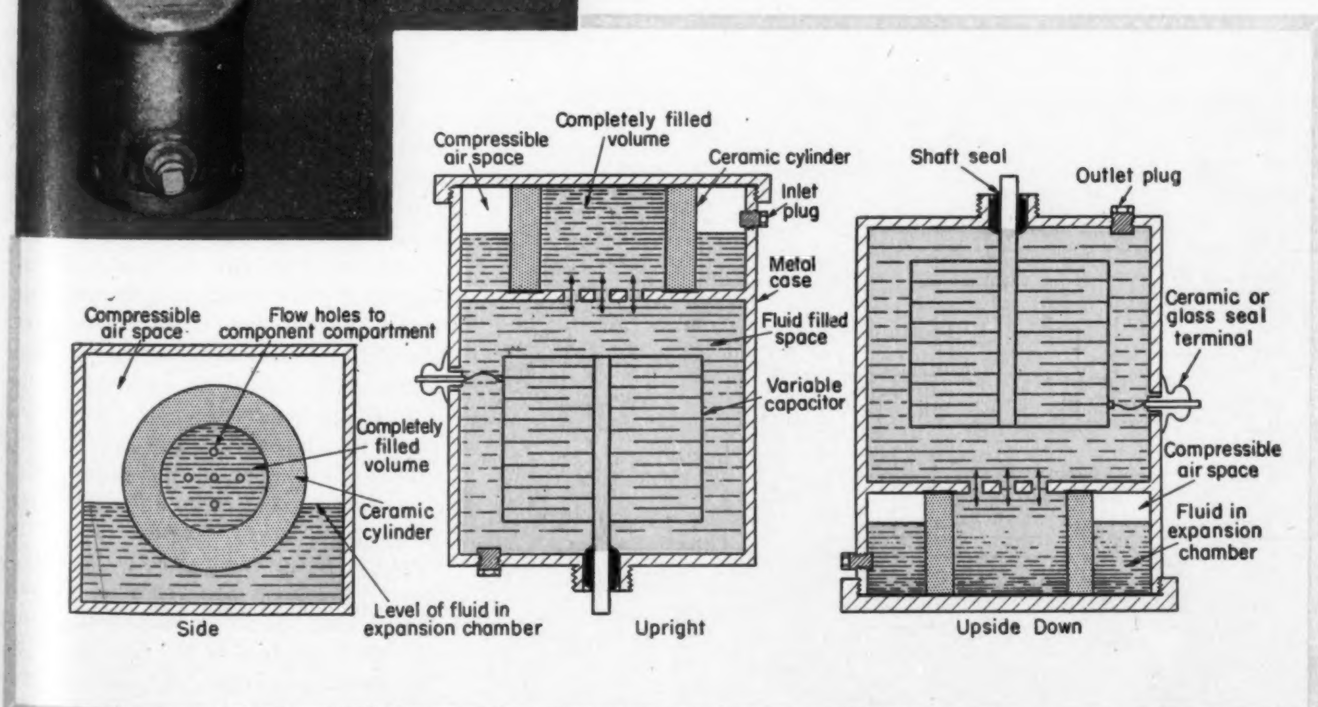
A CLOSED circuit television system developed by the Radio Corporation of America has unlimited potential for monitoring dangerous industrial operations or co-ordinating a number of processes or operations from a central location. The system consists of an 8-lb camera connected to a 58-lb control unit by a coaxial cable. Camera and control box can be separated by as much as 500 feet. The scanning frequency of 525 lines, 60 frames interlaced, is almost comparable with standard television broadcasting techniques and home television sets can easily be adapted for use as monitors.

SCANNING the Field For Ideas

Expansion chambers, utilizing porous ceramic baffles, effectively keep fluid compartments full and free from gas throughout wide temperature variations or changes in attitude. Invented by Sidney Wald, such chambers have been successfully employed in variable tuning capacitors, below, for airborne electronic equipment where maximum utilization of available space is a necessity. The sketches below show how the ceramic baffle fills the capacitor with fluid regardless of position because the baffle passes fluid freely but acts as a barrier to the gases.

During the course of development of an oil-filled capacitor, an expansion device was sought that would withstand military service in a dependable fashion. It would necessarily be inexpensive to fabricate and have unlimited service life. The resulting design employs ceramic filter elements, manufactured by Selas Corp. of America, which pass liquid freely but completely stop the passage of air, provided the ceramic is kept wet by the fluid medium. The ceramic acts as a wick, wetting the capillary pores with the fluid and passing it with negligible resistance to flow. Thus, under varying conditions of temperature the fluid is free to expand into the air space between the outer side of the ceramic cylinder and the inside of the case. As long as the ceramic is wet it remains air-

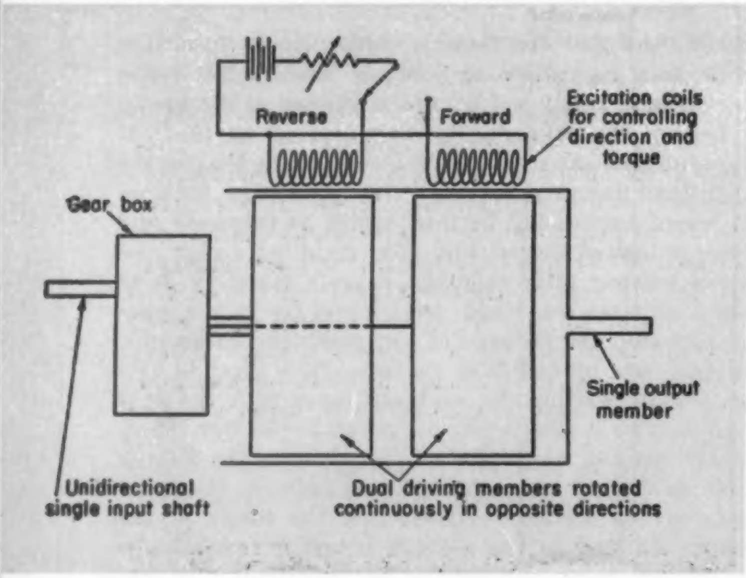




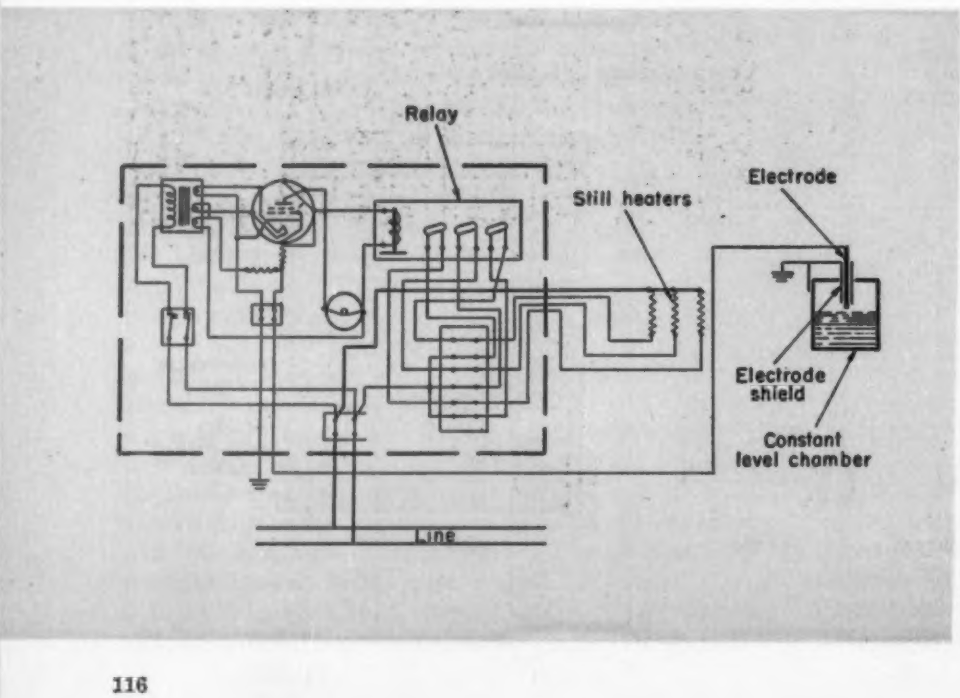
tight and the component enclosed is kept completely immersed. The container must be strong enough to withstand the air pressure due to fluid expansion at the upper temperature limit and operation at high altitudes.

In applying porous baffles of this type it is necessary to know the size of the maximum capillary opening to assure proper operation. This is determined by a bubbling pressure method. When thoroughly saturated with a liquid of known surface tension, the baffle is immersed in the liquid and arranged so that air pressure can be applied against it. The pressure at which air bubbles appear in the liquid is termed the bubbling pressure and is that pressure at which air in the largest opening will displace the liquid. In the capacitors illustrated, this pressure is about 125 psi.

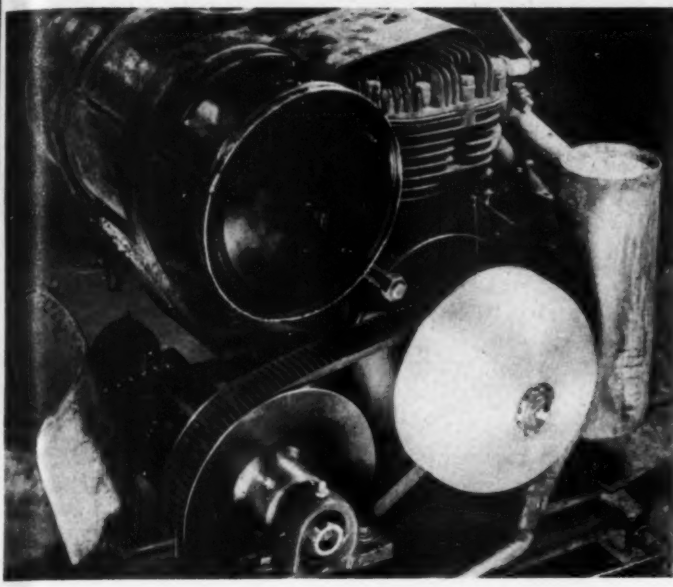
To fill the capacitor, the liquid may be introduced under vacuum or poured through the container with the outlet plug open until all air is removed and the container is completely filled. Then a sufficient amount is drawn off so that the inside pressure will not be excessive at the maximum operating temperature. Development work on the baffle was performed at the RCA Victor Division to whom the patent application has been assigned, and working models were fabricated by the Government Radiation Department. The idea was developed and successfully carried through to production and installation in equipment built by Bendix Radio Communications Division.

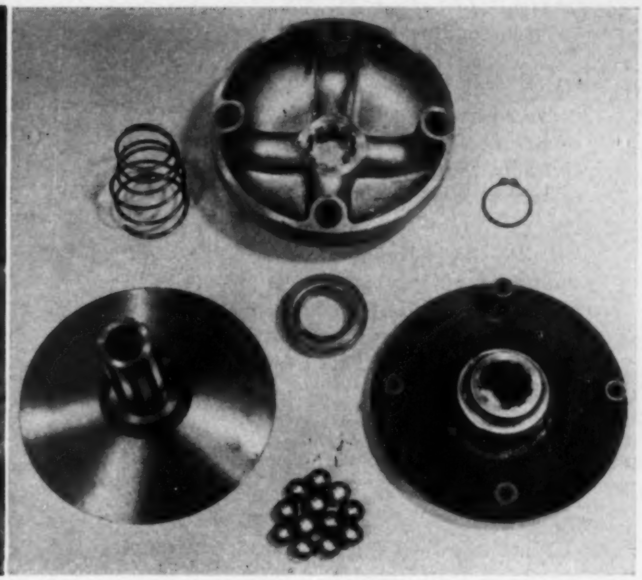


Reversing transmission, shown schematically at left, employs a single low-inertia driven member which has no backlash. As indicated in the diagram, input gearing revolves two driving members in opposite directions. Each being a magnetic-particle clutch, these members control both the direction of rotation and the torque of the output member, depending on which clutch coil is energized and the amount of current flowing. Allowable slippage depends on the heat dissipating characteristics of the clutches. Designed by Vickers Electric Division, the transmission inherently has the features of magnetic-particle clutches including remote control, torque at zero slip, large maximum to minimum torque ratio, fast response, and small control power. A variation of the principle used in this transmission, wherein both driving members would rotate in the same direction, would give a two-range transmission—each having a wide speed variation.



Liquid-level control, shown schematically at left, simply utilizes the liquid level by immersing an electrode in the liquid itself. When the liquid is at the proper level it forms a contact with the electrode, actuating thyratron tubes which keep the relay closed and the power on. Should the level drop below the minimum safe value determined by the tip of the electrode in the gage, the electronic circuit in the control element would become unbalanced and the circuits to the vessel heater elements or other power would be opened to prevent their operation until conditions are restored to normal. This effective and dependable fail-safe control was developed by Precision Scientific Co. for protecting heated stills.

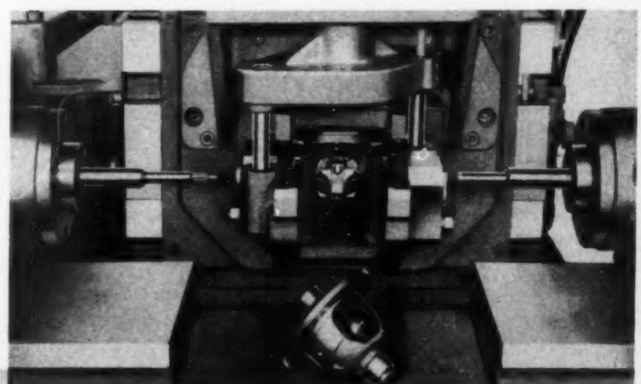


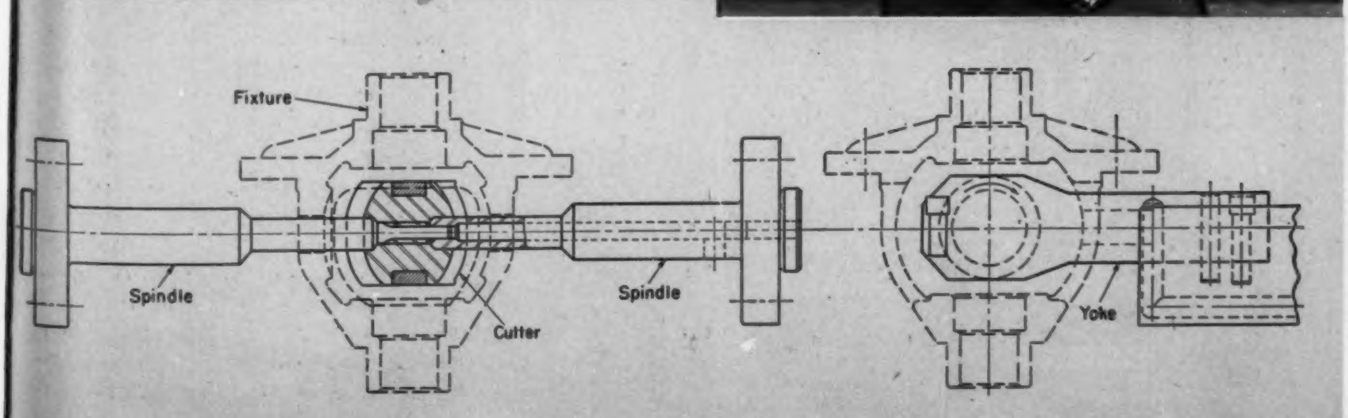


Automatic variable-speed unit, above, depends on engine speed for adjustment of its pulley diameter, thus controlling the speed of the driven elements. Components of this unit, developed by Charles H. Miner and the Driv-way Lite Co., are shown in the photograph above, right. Centrifugally operated, the clutch employs steel balls channeled in a dome cover to position the movable pulley half. When the speed of the engine is increased, centrifugal force of the steel balls pushes against the pulley half, increasing pulley diameter and belt speed. Diameter of the driven pulley is controlled by spring action and is determined by the drive pulley.

Varying performance characteristics may be obtained by inserting larger or smaller balls in the channels, by using aluminum instead of steel balls or by changing the number of balls, depending upon the desired speed, acceleration or overdrive required. The balls become inactive in the outer ends of the channel insofar as clutch positioning is concerned. Centrifugal action is exerted only by those balls in the radial portion of the channels which push the clutch halves together. During idling periods while the clutch is disengaged, the belt rides on an intermediate ball bearing on the pulley shaft, reducing wear on the belt sides.

Yoke holds cutter independent of the cutter drive spindles in the tool, below, to facilitate milling spherical gear seats inside a differential gear case. The carbide cutter is held in the yoke mounted on a stationary bracket. Built by Snyder Tool & Engineering Co., the machine automatically clamps and indexes the workpiece for milling one seat and then the other. Work is loaded over the cutter, the driving arbors engaging the cutter automatically through holes in the workpiece. The spindle is powered by a 3 horsepower motor through belts and helical gears in the head, giving a 40-second fully-automatic work cycle.

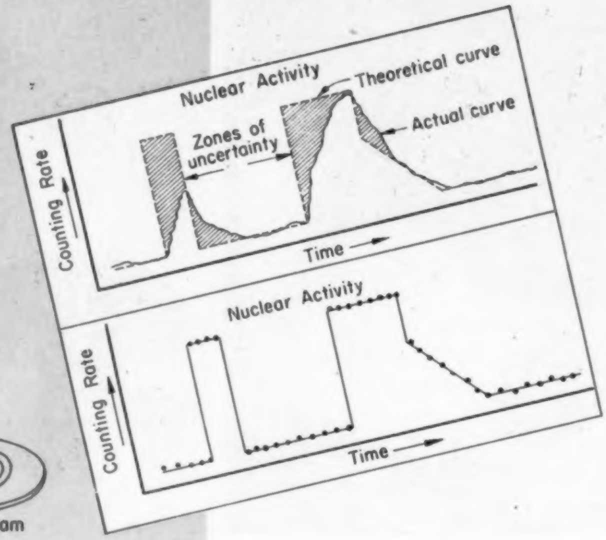


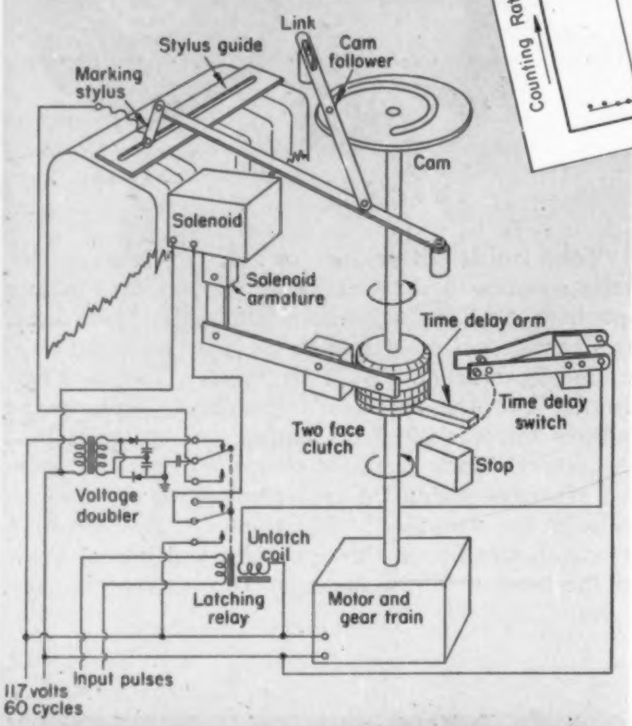


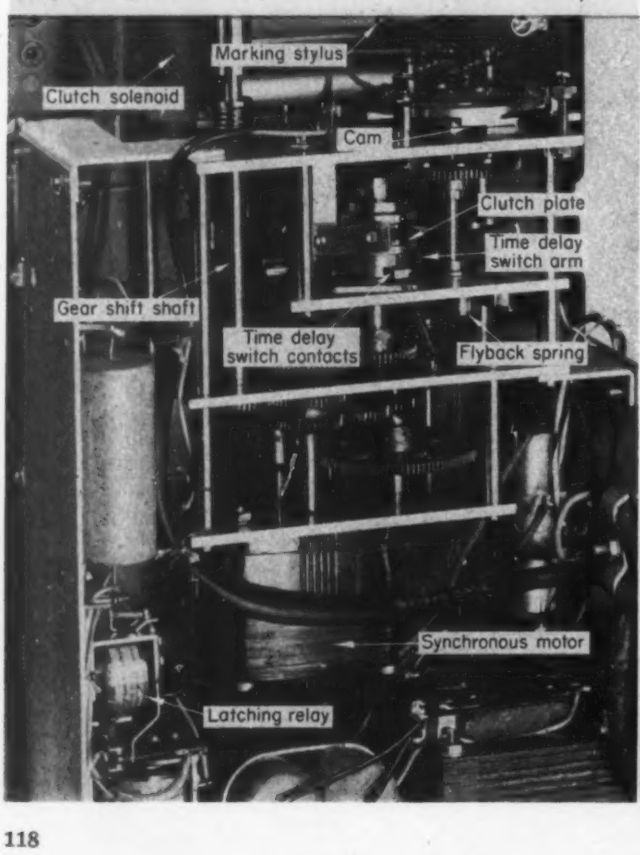
Mecha

Fig. 1 — Right — Response of conventional counting rate meter showing zones of uncertainty that cannot be tolerated in some investigations

Fig. 2 — Right, below — Response of electro-mechanical meter shown by series of dots which closely approximate desired curve in Fig. 1





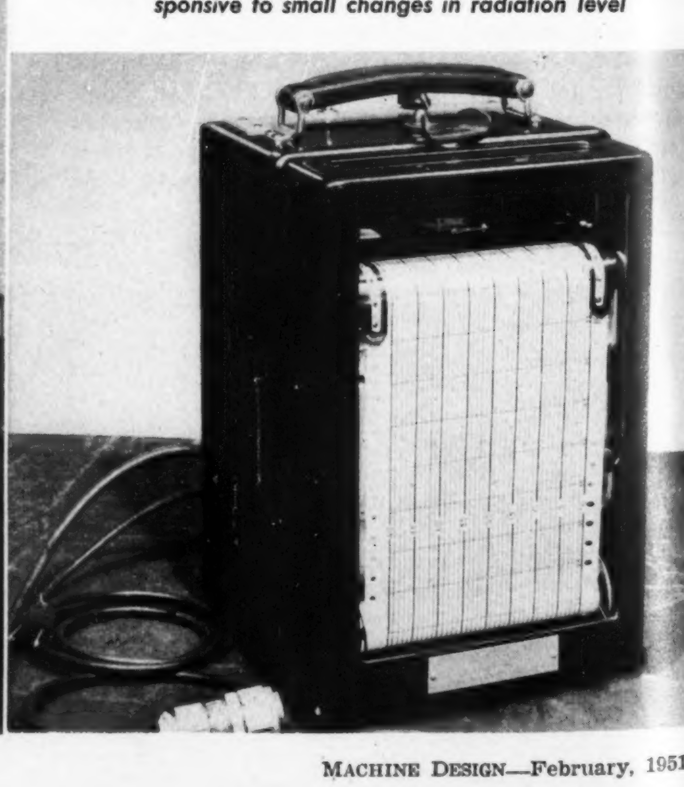


IN THE FIELD of nuclear measurement, there has been a pressing need for a recording meter which will respond immediately to small changes in radiation level without the time delay of conventional counting rate meters. The response of a conventional count-rate meter to changing nuclear activity is shown in *Fig.* 1, shaded areas being "zones of uncertainty". In some nuclear investigations, such as medical and industrial tracer work, these indeter-

Fig. 3—Left—Schematic representation of electromechanical rate meter developed to eliminate inaccuracies of mechanical units giving uncertain readings shown in Fig. 1

Fig. 4—Left, below—Inside view of electromechanical rate meter taken from back with cover removed

Fig. 5—Below—Electromechanical recording rate meter responsive to small changes in radiation level



hal or Electronic Design?

By George J. Giel
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Cost governs choice of design for instrument manufactured in small lots

minate regions contain a major amount of the information desired.

To meet this need an electromechanical computer having the response shown in *Fig.* 2 was designed. It is schematically represented in *Fig.* 3 and pictorially detailed in *Figs.* 4 and 5. The instrument operates in the following manner: The motor and gear train, operating synchronously from a 60-cycle power line, drive the free center member of a two-faced clutch. When this clutch is in its normal position (solenoid unenergized, top face engaged) the marking stylus is driven across the recording paper by linkage from a cam in such a manner that during a predetermined time interval the stylus proceeds on a predetermined schedule from its zero to maximum position.

However, the occurrence of an incoming pulse during this time impresses a high voltage on the marking stylus which records a dot corresponding to its excursion on the sensitive recording paper. The same pulse energizes the solenoid which releases the upper part of the clutch. This allows the cam to return to its starting position (the cam is loaded by a spring not shown) and forces the engagement of the lower face of the clutch to begin the time delay. Then the time delay arm proceeds from the stop until it engages the time delay switch which energizes the unlatch coil of the relay allowing the contacts to

Fig. 6—Right—Response of electronic computer follows closely theoretical curve

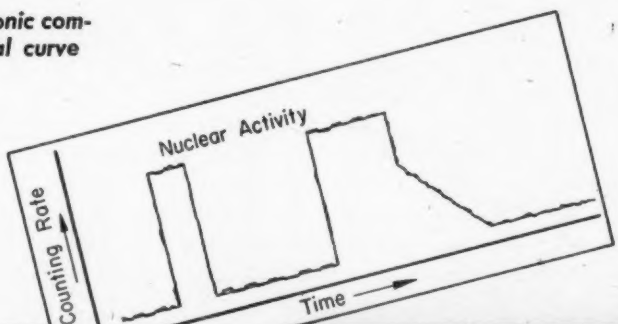
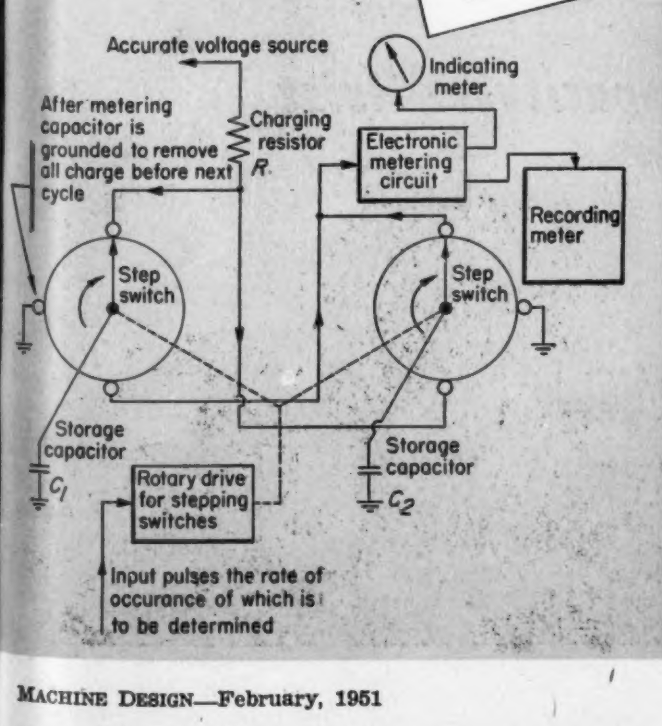


Fig. 7 — Below — Schematic functional diagram of electronic counting rate computer

Fig. 8 — Below — Electronic meter with cover removed for comparison with electromechanical design, illustrated in Fig. 4



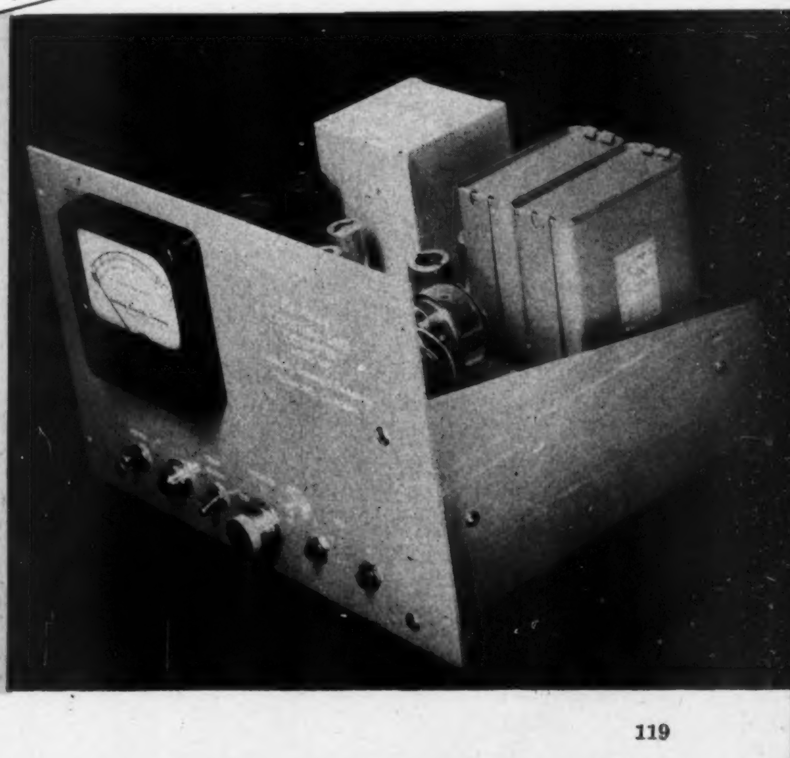


Fig. 9—Electronic counting rate computer and recorder designed for economical low-quantity production

return to their indicated normal position and then permitting the entire cycle to repeat. In this manner a series of dots are plotted through which a curve may be drawn, as in *Fig.* 2, that closely approximates the desired curve of *Fig.* 1.

Highly successful in use, this device operated well within the desired limits of accuracy and exhibited satisfactory dependability. While the need for such equipment is acute, the total number employed by nuclear researchers involves only 200 to 300 a year. Therefore, it was necessary to manufacture on a "model-making" rather than a production basis. Further, if accuracy is to be maintained, close mechanical tolerances are dictated. Such considerations forced the selling price so high that its use by many laboratories and other research organizations was considered to be prohibitive.

It naturally followed that an "all-electronic solution" was considered as an alternative even though it was realized that the generation of specific time-functions is much easier to achieve on the synchronous motor-cam principle. The electronic device with the response shown in *Fig.* 6 was ultimately developed.

This new unit is schematically represented in *Fig.* 7 and shown in *Figs.* 8 and 9. Referring to *Fig.* 7, the rate meter operates as follows: The voltage which the capacitor, C_1 or C_2, will attain when being charged through a known resistor, *R*, is dependent upon the time the capacitance is connected to the charging source. If, then, one input pulse to the instrument connects the capacitor to the charging source and the next input pulse connects it to an accurate electronic metering circuit, the voltage indicated or recorded is in direct relation to the elapsed time between pulses and hence, the rate of occurrence. As is indicated in *Fig.* 7, two capacitors are alternately connected to the charging source and metering circuit so that each reading is completely independent of any previous readings, and a trace such as shown in *Fig.* 6 is produced.

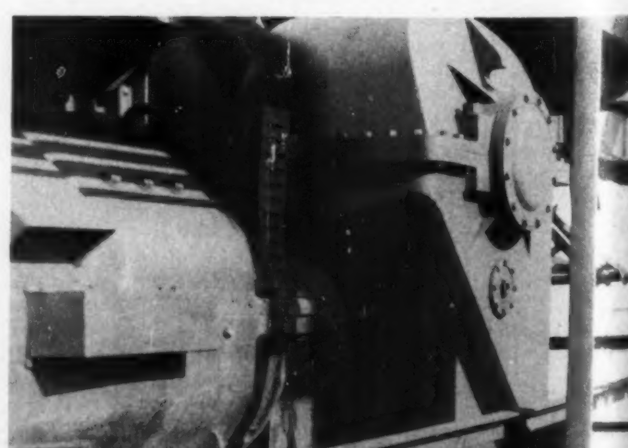
Production Costs One-Fourth

Tests of this electronic computer disclosed it was functionally equal to the electromechanical counterpart and superior in ease of servicing and adjustment. In small quantity, production manufacturing costs proved only one-quarter of those of the previous model. There are several major reasons for this economy: (1) less skilled, lower rate workers may be employed, and (2) assembly and wiring of electronic components may be reduced to routine procedures after initial layouts are complete, whereas model making requires the expensive services of highly skilled machinists. Electronic components are mass-produced in large quantities and, since good design requires no special units, they are relatively inexpensive to procure and stock.

Experience of several years in producing both mechanical and electronic devices has substantiated the results in this particular case.

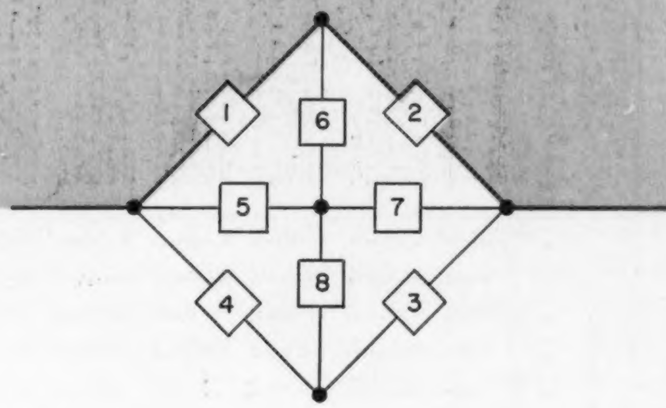
Drive Increases Capacity of Hoist

COMPACT hoist mechanism for manipulating a 25-ton ore bridge bucket plus its 22½-ton load of ore employs two power transmission units mounted on the man-trolley which also carries the machinery for propelling itself the length of the bridge. The drives share the load in varying amounts during hoisting, lowering, opening and closing operations. Each unit consists of a 325-hp, 390-rpm Westinghouse motor, a special 8 to 1 ratio, 24-inch center distance Cone-Drive speed reducer, a 4.92 to 1 ratio second stage spur gear reduction, and a common cable drum with a pitch diameter of slightly over five feet. Handling 22½ tons per load, the bridge, installed at the Gary Steel Works of the Carnegie-Illinois Steel Corp., Gary, Indiana plant, can transfer 24,000 tons of ore per day.



Three-Relay Circuits

. . . Tabulation of formulas simplifies design and analysis



By Edward C. Varnum

Mathematician
Barber-Colman Co.
Rockford, Ill.

Fig. 1—Above—Master network showing the eight possible positions in which relays can be placed

SYSTEMATIC approach to complex circuit problems greatly simplifies analysis. If a relay circuit is represented by a formula, substitution of values corresponding to *open* or *closed* for individual relays of the circuit will tell whether the entire circuit is open or closed. In a previous article[1], a table of circuits was given for each of the 16 different arrangements of two independent relays together with theorems by which formulas for desired circuits can be obtained by expansions about one relay at a time. The present article extends the table to the 256 circuits obtainable by the use of, at most, three independent relays. Also, by use of the binary number system and matrix notation an expansion theorem for any number of relays is explained.

ODD-EVEN ALGEBRA: The mathematical system used in this method of relay circuit analysis is a simplified type of algebra which deals only with integers and is concerned only with the question of whether the integer is odd or even[1]. For convenience, all odd integers are written as 1 (one), all even integers are written as 0 (zero). Multiplication has the same appearance as in ordinary arithmetic. Addition has one superficial difference in appearance, namely, $1 + 1 = 0$, which arises because it was agreed to call 2 (an even number) the same as 0. In the algebraic manipulations no exponents or coefficients are needed because any power of a number is always the number itself and any number added to itself yields zero.

BINARY NUMBERS: A binary number consists of a series of 1's and 0's which tell whether the corresponding power of 2 is or is not to be used in the value of the number. As in the decimal system, the powers increase as the number progresses from right to left, so that the highest power of 2 is the first one encountered in reading the binary number in the customary manner. For example, in a four-digit binary number such as 1111 the first digit would represent $2^3 = 8$, the second $2^2 = 4$, the third $2^1 = 2$, and the last digit (as always) $2^0 = 1$. The decimal equivalent of the binary number 1111 would therefore be $8 + 4 + 2 + 1 = 15$. However, if the binary number were 1101 the corresponding decimal number would be $8 + 4 + 1 = 13$.

A convenient method of converting to the decimal system from the binary system is by what may be termed "doubling and dabbling" where "dabble" means "double and add one." The method proceeds from left to right in the following manner:

(a) The first digit is generally a 1, so think "1"
(b) If the second digit is 0, double the 1 and think "2"
(c) If the second digit is 1, dabble the 1 and think "3"
(d) Continue doubling or dabbling as above until the number is ended.

For example, as in the foregoing numerical example,

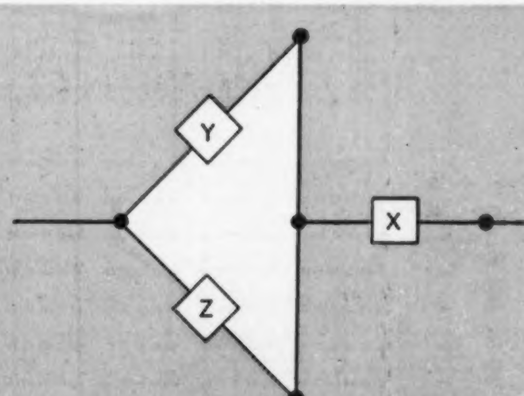


Fig. 2—Circuit corresponding to test number 224 in Table 1. Comparing with Fig. 1 and the circuit column in Table 1, it will be noted that Y, Z, and X are placed in positions 1, 4 and 7 respectively, positions 2, 3 and 5 are permanently open, and positions 6 and 8 are permanently closed

[1] References are listed at end of article.

Table 1—Circuits Using Three Relays

Test Number T	Binary	Circuit (see Fig. 1) 1	2	3	4	5	6	7	8	Formula	F
0	0 0 0 0 0 0 0 0	0	0	0	0	0	0	0	0	0	0
1	0 0 0 0 0 0 0 1	X'	0	0	0	0	Y'	Z'	0	XYZ+XY+XZ+X+YZ+Y+Z+1	255
2	0 0 0 0 0 0 1 0	X'	0	0	0	0	Y'	Z	0	XYZ+XZ+YZ+Z	170
3	0 0 0 0 0 0 1 1	X'	Y'	0	0	0	0	0	0	XY+X+Y+1	85
4	0 0 0 0 0 1 0 0	X'	0	0	0	0	Y	Z'	0	XYZ+XY+YZ+Y	204
5	0 0 0 0 0 1 0 1	X'	Z'	0	0	0	0	0	0	XZ+X+Z+1	51
6	0 0 0 0 0 1 1 0	0	Z'	Z	0	X'	Y	0	Y'	XY+XZ+Y+Z	102
7	0 0 0 0 0 1 1 1	X'	Y'	0	0	0	Z'	1	0	XYZ+X+YZ+1	153
8	0 0 0 0 1 0 0 0	X'	0	0	0	0	Y	Z	0	XYZ+YZ	136
9	0 0 0 0 1 0 0 1	0	Z	Z'	0	X'	Y	0	Y'	XY+XZ+X+Y+Z+1	119
10	0 0 0 0 1 0 1 0	X'	Z	0	0	0	0	0	0	XZ+Z	34
11	0 0 0 0 1 0 1 1	X'	Y'	0	0	0	Z	1	0	XYZ+XY+X+YZ+Y+1	221
12	0 0 0 0 1 1 0 0	X'	Y	0	0	0	0	0	0	XY+Y	68
13	0 0 0 0 1 1 0 1	X'	Y	0	0	0	Z'	1	0	XYZ+XZ+X+YZ+Z+1	187
14	0 0 0 0 1 1 1 0	X'	Y	0	0	0	Z	1	0	XYZ+XY+XZ+YZ+Y+Z	238
15	0 0 0 0 1 1 1 1	X'	1	0	0	0	0	0	0	X+1	17
16	0 0 0 1 0 0 0 0	X	0	0	0	0	Y'	Z'	0	XYZ+XY+XZ+X	240
17	0 0 0 1 0 0 0 1	Y'	Z'	0	0	0	0	0	0	YZ+Y+Z+1	15
18	0 0 0 1 0 0 1 0	0	Z'	Z	0	Y'	X	0	X'	XY+X+YZ+Z	90
19	0 0 0 1 0 0 1 1	Y'	X'	0	0	0	Z'	1	0	XYZ+XZ+Y+1	165
20	0 0 0 1 0 1 0 0	0	Y'	Y	0	Z'	X	0	X'	XZ+X+YZ+Y	60
21	0 0 0 1 0 1 0 1	Z'	Y'	0	0	0	X'	1	0	XYZ+XY+Z+1	195
22	0 0 0 1 0 1 1 0	Z'	Z	Z'	0	X'	Y'	X	Y	XYZ+X+Y+Z	150
23	0 0 0 1 0 1 1 1	X'	Y'	0	X	0	X'	Z'	Y'	XY+XZ+YZ+1	105
24	0 0 0 1 1 0 0 0	0	Z'	0	Z	X	Y'	X'	Y	XY+XZ+X+YZ	120
25	0 0 0 1 1 0 0 1	Y'	Z'	Z	0	X'	Y'	0	Y	XYZ+Y+Z+1	135
26	0 0 0 1 1 0 1 0	X	0	Z	X'	0	Y'	Z'	0	XYZ+XY+X+Z	210
27	0 0 0 1 1 0 1 1	X	0	1	0	X'	Z'	Y'	Z	XZ+YZ+Y+1	45
28	0 0 0 1 1 1 0 0	X	0	Y	X'	0	Y'	Z'	0	XYZ+XZ+X+Y	180
29	0 0 0 1 1 1 0 1	X	0	1	0	X'	Y'	Z'	Y	XY+YZ+Z+1	75
30	0 0 0 1 1 1 1 0	X	0	X'	Y	Z	Y'	Z'	1	X+YZ+Y+Z	30
31	0 0 0 1 1 1 1 1	X'	1	Z'	Y'	0	0	0	0	XYZ+XY+XZ+1	225
32	0 0 1 0 0 0 0 0	X	0	0	0	0	Y'	Z	0	XYZ+XZ	160
33	0 0 1 0 0 0 0 1	0	Z	Z'	0	Y'	X	0	X'	XY+X+YZ+Y+Z+1	95
34	0 0 1 0 0 0 1 0	Y'	Z	0	0	0	0	0	0	YZ+Z	10
35	0 0 1 0 0 0 1 1	Y'	X'	0	0	1	Z	0	0	XYZ+XY+XZ+X+Y+1	245
36	0 0 1 0 0 1 0 0	Y'	0	Z'	0	X'	Z	X	Y	XY+XZ+YZ+Y	108
37	0 0 1 0 0 1 0 1	X'	Z'	Z	0	X	0	0	Y'	XYZ+X+Z+1	147
38	0 0 1 0 0 1 1 0	X'	0	Z	Y'	0	Y	Z'	0	XYZ+XY+Y+Z	198
39	0 0 1 0 0 1 1 1	X	0	Z'	X'	0	Z	Y'	1	XZ+X+YZ+1	57
40	0 0 1 0 1 0 0 0	0	Y'	Y	0	Z	X	0	X'	XZ+YZ	40
41	0 0 1 0 1 0 0 1	Y'	Y	Y'	0	Z	X'	Z'	X	XYZ+XY+X+Y+Z+1	215
42	0 0 1 0 1 0 1 0	Z	X'	0	0	0	1	Y'	0	XYZ+Z	130
43	0 0 1 0 1 0 1 1	Z	X'	0	1	0	Y'	X	X'	XY+XZ+X+YZ+Y+1	125
44	0 0 1 0 1 1 0 0	X	0	Y	X'	0	Y'	Z	0	XYZ+XY+XZ+Y	228
45	0 0 1 0 1 1 0 1	X	0	X'	Y	Z'	Y'	Z	1	X+YZ+Z+1	27
46	0 0 1 0 1 1 1 0	X	0	Y	0	X'	Y'	Z	1	XY+YZ+Y+Z	78
47	0 0 1 0 1 1 1 1	X	0	1	X'	0	Y'	Z	0	XYZ+XZ+X+1	177
48	0 0 1 1 0 0 0 0	X	Y'	0	0	0	0	0	0	XY+X	80
49	0 0 1 1 0 0 0 1	Y'	X	0	0	0	Z'	1	0	XYZ+XZ+YZ+Y+Z+1	175
50	0 0 1 1 0 0 1 0	Y'	X	0	0	0	Z	1	0	XYZ+XY+XZ+X+YZ+Z	250
51	0 0 1 1 0 0 1 1	Y'	1	0	0	0	0	0	0	Y+1	5
52	0 0 1 1 0 1 0 0	X	Y'	0	X'	0	0	Z'	Y	XYZ+X+YZ+Y	156
53	0 0 1 1 0 1 0 1	X	Y'	Z'	X'	0	0	0	0	XY+XZ+Z+1	99
54	0 0 1 1 0 1 1 0	X	Y'	Y	0	X'	Z	0	Z'	XZ+X+Y+Z	54
55	0 0 1 1 0 1 1 1	Y'	1	Z'	X'	0	0	0	0	XYZ+XY+YZ+1	201
56	0 0 1 1 1 0 0 0	X	Y'	Z	0	X'	0	0	Y	XYZ+XY+X+YZ	216
57	0 0 1 1 1 0 0 1	X	Y'	Y	0	X'	Z'	0	Z	XZ+Y+Z+1	39
58	0 0 1 1 1 0 1 0	X	Y'	Z	X'	0	0	0	0	XY+XZ+X+Z	114
59	0 0 1 1 1 0 1 1	Y'	1	Z	X'	0	0	0	0	XYZ+YZ+Y+1	141
60	0 0 1 1 1 1 0 0	X	Y'	Y	X'	0	0	0	0	X+Y	20

Test Number T	Binary	Circuit (see Fig. 1) 1	2	3	4	5	6	7	8	Formula	F
128	1 0 0 0 0 0 0 0	X	0	0	0	0	Y	Z	0	XYZ	128
129	1 0 0 0 0 0 0 1	X	0	X'	0	Z'	Y	Z	Y'	XY+XZ+X+YZ+Y+Z+1	127
130	1 0 0 0 0 0 1 0	Y'	0	0	Y	0	X'	Z	X	XZ+YZ+Z	42
131	1 0 0 0 0 0 1 1	X	0	Y'	X'	0	Y	Z	0	XYZ+XY+X+Y+1	213
132	1 0 0 0 0 1 0 0	Z'	0	0	Z	0	X'	Y	X	XY+YZ+Y	76
133	1 0 0 0 0 1 0 1	X	0	Z'	X'	0	Y	Z	0	XYZ+XZ+X+Z+1	179
134	1 0 0 0 0 1 1 0	X	X'	0	X'	Z'	Y	Z	Y'	XYZ+XY+XZ+Y+Z	230
135	1 0 0 0 0 1 1 1	X	0	X'	Y'	Z'	Y	Z	1	X+YZ+1	25
136	1 0 0 0 1 0 0 0	Y	Z	0	0	0	0	0	0	YZ	8
137	1 0 0 0 1 0 0 1	X'	0	Z	Y	0	Y'	Z'	0	XYZ+XY+XZ+X+Y+Z+1	247
138	1 0 0 0 1 0 1 0	Z	X'	0	0	0	1	Y	0	XYZ+XZ+Z	162
139	1 0 0 0 1 0 1 1	X'	Y'	Z	Y	0	0	0	0	XY+X+YZ+Y+1	93
140	1 0 0 0 1 1 0 0	Y	X'	0	0	0	1	Z	0	XYZ+XY+Y	196
141	1 0 0 0 1 1 0 1	X	0	1	0	X'	Z	Y	Z'	XZ+X+YZ+Z+1	59
142	1 0 0 0 1 1 1 0	X	X'	0	0	X'	Y	Z	0	XY+XZ+YZ+Y+Z	110
143	1 0 0 0 1 1 1 1	X'	1	Z	Y	0	0	0	0	XYZ+X+1	145
144	1 0 0 1 0 0 0 0	Y	0	0	Y'	0	Z	X	Z'	XY+XZ+X	112
145	1 0 0 1 0 0 0 1	X	0	Z'	Y'	0	Y	Z	0	XYZ+YZ+Y+Z+1	143
146	1 0 0 1 0 0 1 0	Z'	Z	0	Z	Y	X	Y'	X'	XYZ+XY+X+YZ+Z	218
147	1 0 0 1 0 0 1 1	Y'	X'	0	Y	0	Z'	X	Z	XZ+Y+1	37
148	1 0 0 1 0 1 0 0	Y	Y'	Y	0	Z'	X	Z	X'	XYZ+XZ+X+YZ+Y	188
149	1 0 0 1 0 1 0 1	Y'	Y	0	1	Z	X	Z'	X'	XY+Z+1	67
150	1 0 0 1 0 1 1 0	X'	X	X'	X	Z	Y	Z'	Y'	X+Y+Z	22
151	1 0 0 1 0 1 1 1	Z'	X'	0	Z	X'	Y'	X	Y	XYZ+XY+XZ+YZ+1	233
152	1 0 0 1 1 0 0 0	X	0	Z	Y	0	Y'	Z'	0	XYZ+XY+XZ+X+YZ	248
153	1 0 0 1 1 0 0 1	Y	Z	Z'	Y'	0	0	0	0	Y+Z+1	7
154	1 0 0 1 1 0 1 0	X'	Z	Z'	0	X	Y	0	Y'	XY+X+Z	82
155	1 0 0 1 1 0 1 1	Z	X'	Y'	Z'	0	1	Y	0	XYZ+XZ+YZ+Y+1	173
156	1 0 0 1 1 1 0 0	X'	Y	Z'	0	X	Z	0	Y'	XZ+X+Y	52
157	1 0 0 1 1 1 0 1	X'	Y	Y'	Z'	Z	1	0	0	XYZ+XY+YZ+Z+1	203
158	1 0 0 1 1 1 1 0	X'	Z	Z'	0	X	Y	X'	Y'	XYZ+X+YZ+Y+Z	158
159	1 0 0 1 1 1 1 1	Y	Z	Z'	Y'	X'	0	1	0	XY+XZ+1	97
160	1 0 1 0 0 0 0 0	X	Z	0	0	0	0	0	0	XZ	32
161	1 0 1 0 0 0 0 1	X	Z	0	X'	0	0	Z'	Y'	XYZ+XY+X+YZ+Y+Z+1	223
162	1 0 1 0 0 0 1 0	Z	X	0	0	0	1	Y'	0	XYZ+YZ+Z	138
163	1 0 1 0 0 0 1 1	X	Z	Y'	X'	0	0	0	0	XY+XZ+X+Y+1	117
164	1 0 1 0 0 1 0 0	X	Z	0	X'	0	0	Y	Z'	XYZ+XY+XZ+YZ+Y	236
165	1 0 1 0 0 1 0 1	X	Z	Z'	X'	0	0	0	0	X+Z+1	19
166	1 0 1 0 0 1 1 0	X	Z	Z'	0	0	Y	X'	Y'	XY+Y+Z	70
167	1 0 1 0 0 1 1 1	X	Z	Z'	X'	0	0	Y'	1	XYZ+XZ+X+YZ+1	185
168	1 0 1 0 1 0 0 0	X	0	0	0	Y	1	Z	0	XYZ+XZ+YZ	168
169	1 0 1 0 1 0 0 1	X	Z	Z'	0	X'	Y	0	Y'	XY+X+Y+Z+1	87
170	1 0 1 0 1 0 1 0	Z	1	0	0	0	0	0	0	Z	2
171	1 0 1 0 1 0 1 1	Z	1	Y'	X'	0	0	0	0	XYZ+XY+XZ+X+YZ+Y+1	253
172	1 0 1 0 1 1 0 0	X	Z	Y	X'	0	0	0	0	XY+XZ+Y	100
173	1 0 1 0 1 1 0 1	X	Z	Z'	0	X'	0	Y	1	XYZ+X+YZ+Z+1	155
174	1 0 1 0 1 1 1 0	Z	1	Y	X'	0	0	0	0	XYZ+XY+YZ+Y+Z	206
175	1 0 1 0 1 1 1 1	X'	1	Z	1	0	0	0	0	XZ+X+1	49
176	1 0 1 1 0 0 0 0	Y'	0	0	0	Z	1	X	0	XYZ+XY+X	208
177	1 0 1 1 0 0 0 1	Y'	0	X'	0	Z	1	X	Z'	XZ+YZ+Y+Z+1	47
178	1 0 1 1 0 0 1 0	Y'	Z	0	0	Y	X	Y'	0	XY+XZ+X+YZ+Z	122
179	1 0 1 1 0 0 1 1	X	Z	1	Y'	0	0	0	0	XYZ+Y+1	133
180	1 0 1 1 0 1 0 0	X	Y'	X'	0	Z'	1	Z	Y	X+YZ+Y	28
181	1 0 1 1 0 1 0 1	X	Z	Z'	X'	0	1	Y'	0	XYZ+XY+XZ+Z+1	227
182	1 0 1 1 0 1 1 0	Y'	Z	Z'	0	Y	X	Y'	X'	XYZ+XZ+X+Y+Z	182
183	1 0 1 1 0 1 1 1	X'	Y'	Z'	X'	X	1	Z	0	XY+YZ+1	73
184	1 0 1 1 1 0 0 0	Y'	X	X'	0	Z	1	0	Y	XY+X+YZ	88
185	1 0 1 1 1 0 0 1	Y'	Z'	0	Y	X	0	Z	1	XYZ+XZ+Y+Z+1	167
186	1 0 1 1 1 0 1 0	X	Y'	1	Z	0	0	0	0	XYZ+XY+XZ+X+Z	242
187	1 0 1 1 1 0 1 1	Y'	1	1	Z	0	0	0	0	YZ+Y+1	13
188	1 0 1 1 1 1 0 0	Y	X'	0	Y'	Z	0	X	1	XYZ+X+Y	148
189	1 0 1 1 1 1 0 1	X	X'	Y'	Y	Z'	1	Z	1	XY+XZ+YZ+Z+1	107

61	0 0 1 1 1 1 0 1	X	Y'	Z'	0	X'	0	Y	1	XYZ+XY+XZ+YZ+Z+1	235
62	0 0 1 1 1 1 1 0	X	Y'	Z	0	X'	0	Y	1	XYZ+XZ+X+YZ+Y+Z	190
63	0 0 1 1 1 1 1 1	X'	1	Y'	1	0	0	0	0	XY+1	65
64	0 1 0 0 0 0 0 0	X	0	0	0	0	Y	Z'	0	XYZ+XY	192
65	0 1 0 0 0 0 0 1	0	Y	Y'	0	Z'	X	0	X'	XZ+X+YZ+Y+Z+1	63
66	0 1 0 0 0 0 1 0	Z	0	Z'	0	X	Y'	X'	Y	XY+XZ+YZ+Z	106
67	0 1 0 0 0 0 1 1	X	0	Y'	X'	0	Y	Z'	0	XYZ+X+Y+1	149
68	0 1 0 0 0 1 0 0	Y	Z'	0	0	0	0	0	0	YZ+Y	12
69	0 1 0 0 0 1 0 1	Z'	X'	0	0	0	1	Y	0	XYZ+XY+XZ+X+Z+1	243
70	0 1 0 0 0 1 1 0	X'	0	Z'	Y	0	Y'	Z	0	XYZ+XZ+Y+Z	166
71	0 1 0 0 0 1 1 1	X	0	1	0	X'	Y	Z'	Y'	XY+X+YZ+1	89
72	0 1 0 0 1 0 0 0	0	Z'	Z	0	Y	X	0	X'	XY+YZ	72
73	0 1 0 0 1 0 0 1	Z	Z'	0	Z'	Y'	X'	Y	X	XYZ+XZ+X+Y+Z+1	183
74	0 1 0 0 1 0 1 0	X	0	Z	X'	0	Y	Z'	0	XYZ+XY+XZ+Z	226
75	0 1 0 0 1 0 1 1	X	0	X'	Y'	Z	Y	Z'	Y'	X+YZ+Y+1	29
76	0 1 0 0 1 1 0 0	Y	X'	0	0	0	Z'	1	0	XYZ+Y	132
77	0 1 0 0 1 1 0 1	X	0	Z'	X'	0	Z'	Y	Y	XY+XZ+X+YZ+Z+1	123
78	0 1 0 0 1 1 1 0	X	0	1	0	X'	Z'	Y	Z	XZ+YZ+Y+Z	46
79	0 1 0 0 1 1 1 1	X'	1	Z'	Y	0	0	0	0	XYZ+XY+X+1	209
80	0 1 0 1 0 0 0 0	X	Z'	0	0	0	0	0	0	XZ+X	48
81	0 1 0 1 0 0 0 1	Z'	X	0	0	0	1	Y'	0	XYZ+XY+YZ+Y+Z+1	207
82	0 1 0 1 0 0 1 0	X	Z'	0	X'	0	0	Z	Y'	XYZ+X+YZ+Z	154
83	0 1 0 1 0 0 1 1	X	Z'	Y'	X'	0	0	0	0	XY+XZ+Y+1	101
84	0 1 0 1 0 1 0 0	Z'	X	0	0	0	1	Y	0	XYZ+XY+XZ+X+YZ+Y	252
85	0 1 0 1 0 1 0 1	Z'	1	0	0	0	0	0	0	Z+1	3
86	0 1 0 1 0 1 1 0	Z	0	Z'	X	Y	X'	Y'	1	XY+X+Y+Z	86
87	0 1 0 1 0 1 1 1	X'	Y'	1	Z'	0	0	0	0	XYZ+XZ+YZ+1	169
88	0 1 0 1 1 0 0 0	X	Z'	0	X'	0	0	Z	Y	XYZ+XZ+X+YZ	184
89	0 1 0 1 1 0 0 1	Z	0	X	Z'	0	Y	X'	Y'	XY+Y+Z+1	71
90	0 1 0 1 1 0 1 0	X	Z'	Z	X'	0	0	0	0	X+Z	18
91	0 1 0 1 1 0 1 1	X	Z'	Z	X'	0	0	1	Y'	XYZ+XY+XZ+YZ+Y+1	237
92	0 1 0 1 1 1 0 0	X	Z'	Y	X'	0	0	0	0	XY+XZ+X+Y	116
93	0 1 0 1 1 1 0 1	Z'	1	Y	X'	0	0	0	0	XYZ+YZ+Z+1	139
94	0 1 0 1 1 1 1 0	X'	Z	X	Z'	0	0	Y	1	XYZ+XY+X+YZ+Y+Z	222
95	0 1 0 1 1 1 1 1	X'	1	Z'	1	0	0	0	0	XZ+1	33
96	0 1 1 0 0 0 0 0	Z	0	0	Z'	0	Y'	X	Y	XY+XZ	96
97	0 1 1 0 0 0 0 1	Z	Z'	0	Z'	X'	Y'	X	Y	XYZ+X+YZ+Y+Z+1	159
98	0 1 1 0 0 0 1 0	X	0	Z	Y'	0	Y	Z'	0	XYZ+XY+YZ+Z	202
99	0 1 1 0 0 0 1 1	X'	Y'	Y	0	X	Z	0	Z'	XZ+X+Y+1	53
100	0 1 1 0 0 1 0 0	X	0	Z'	Y	0	Y'	Z	0	XYZ+XZ+YZ+Y	172
101	0 1 1 0 0 1 0 1	X'	Z'	Z	0	X	Y	0	Y'	XY+X+Z+1	83
102	0 1 1 0 0 1 1 0	Y	Z'	Z	Y'	0	0	0	0	Y+Z	6
103	0 1 1 0 0 1 1 1	Y'	X'	Z'	Y	0	1	Z	0	XYZ+XY+XZ+X+YZ+1	249
104	0 1 1 0 1 0 0 0	Z	Z'	Z	0	X	Y	X'	Y'	XYZ+XY+XZ+YZ	232
105	0 1 1 0 1 0 0 1	Z	Z'	Z	Z'	X	Y	X'	Y'	X+Y+Z+1	23
106	0 1 1 0 1 0 1 0	Z	Z'	Z	X'	X	Y	0	Y'	XY+Z	66
107	0 1 1 0 1 0 1 1	Z	Y'	Y	0	Z'	X'	Z	X	XYZ+XZ+X+YZ+Y+1	189
108	0 1 1 0 1 1 0 0	X'	Y	Y'	0	X	Z'	0	Z	XZ+Y	36
109	0 1 1 0 1 1 0 1	Y	Z'	Z	0	Y'	X'	Y	X	XYZ+XY+X+YZ+Z+1	219
110	0 1 1 0 1 1 1 0	Y	X'	Z	Y'	0	1	Z'	0	XYZ+YZ+Y+Z	142
111	0 1 1 0 1 1 1 1	Y	Z'	Z	Y'	X'	0	1	0	XY+XZ+X+1	113
112	0 1 1 1 0 0 0 0	X	Y'	0	0	0	1	Z'	0	XYZ+X	144
113	0 1 1 1 0 0 0 1	X	Z'	0	0	X'	Y'	X	0	XY+XZ+YZ+Y+Z+1	111
114	0 1 1 1 0 0 1 0	X	Y'	Z'	X	X'	Z	0	0	XZ+X+YZ+Z	58
115	0 1 1 1 0 0 1 1	X	Z'	1	Y'	0	0	0	0	XYZ+XY+Y+1	197
116	0 1 1 1 0 1 0 0	X	Z'	Y'	X	X'	Y	0	0	XY+X+YZ+Y	92
117	0 1 1 1 0 1 0 1	X	Y'	1	Z'	0	0	0	0	XYZ+XZ+Z+1	163
118	0 1 1 1 0 1 1 0	Z'	X	X	Y'	0	Y	X'	Z	XYZ+XY+XZ+X+Y+Z	246
119	0 1 1 1 0 1 1 1	Y'	1	1	Z'	0	0	0	0	YZ+1	9
120	0 1 1 1 1 0 0 0	X	Y'	X'	0	Z	1	Z'	Y	YZ+X	24
121	0 1 1 1 1 0 0 1	X	Z'	Z	0	X'	Y'	X	Y	XYZ+XY+XZ+Y+Z+1	231
122	0 1 1 1 1 0 1 0	X	Y'	Z	X'	0	1	Z'	0	XYZ+XZ+X+Z	178
123	0 1 1 1 1 0 1 1	X	Z'	Z	X'	Y'	0	1	0	XY+YZ+Y+1	77
124	0 1 1 1 1 1 0 0	X	Z'	Y	X'	0	Y'	1	0	XYZ+XY+X+Y	212
125	0 1 1 1 1 1 0 1	X	Y'	Y	X'	Z'	0	1	0	XZ+YZ+Z+1	43
126	0 1 1 1 1 1 1 0	X	Y'	Z	X'	0	Z'	1	Y	XY+XZ+X+YZ+Y+Z	126
127	0 1 1 1 1 1 1 1	X'	1	1	Z'	Y'	0	1	0	XYZ+1	129

190	1 0 1 1 1 1 1 0	X'	Z	Y	X'	X	X	Y'	0	XZ+X+YZ+Y+Z	62
191	1 0 1 1 1 1 1 1	X'	1	1	Y'	Z	0	1	0	XYZ+XY+1	193
192	1 1 0 0 0 0 0 0	X	Y	0	0	0	0	0	0	XY	64
193	1 1 0 0 0 0 0 1	X	Y	0	X'	0	0	Z'	Y'	XYZ+XZ+X+YZ+Y+Z+1	191
194	1 1 0 0 0 0 1 0	X	Y	0	X'	0	0	Z	Y'	XYZ+XY+XZ+YZ+Z	234
195	1 1 0 0 0 0 1 1	X	Y	Y'	X'	0	0	0	0	X+Y+1	21
196	1 1 0 0 0 1 0 0	X	0	0	Z'	0	1	Y	1	XYZ+YZ+Y	140
197	1 1 0 0 0 1 0 1	X	Y	Z'	X'	0	0	0	0	XY+XZ+X+Z+1	115
198	1 1 0 0 0 1 1 0	X	Y	Y'	0	X'	Z'	0	Z	XZ+Y+Z	38
199	1 1 0 0 0 1 1 1	X	Y	Z'	0	X'	0	Y'	1	XYZ+XY+X+YZ+1	217
200	1 1 0 0 1 0 0 0	X	0	0	Z	0	1	Y	1	XYZ+XY+YZ	200
201	1 1 0 0 1 0 0 1	X	Y	Y'	0	X'	Z	0	Z'	XZ+X+Y+Z+1	55
202	1 1 0 0 1 0 1 0	X	Y	Z	X'	0	0	0	0	XY+XZ+Z	98
203	1 1 0 0 1 0 1 1	X	Y	Z	0	X'	0	Y'	1	XYZ+X+YZ+Y+1	157
204	1 1 0 0 1 1 0 0	Y	1	0	0	0	0	0	0	Y	4
205	1 1 0 0 1 1 0 1	Y	1	X'	Z'	0	0	0	0	XYZ+XY+XZ+X+YZ+Z+1	251
206	1 1 0 0 1 1 1 0	Y	1	X'	Z	0	0	0	0	XYZ+XZ+YZ+Y+Z	174
207	1 1 0 0 1 1 1 1	X'	1	Y	1	0	0	0	0	XY+X+1	81
208	1 1 0 1 0 0 0 0	Y	0	0	Z'	0	1	X	1	XYZ+XZ+X	176
209	1 1 0 1 0 0 0 1	X	Y	0	X'	0	1	Z'	Y'	XY+YZ+Y+Z+1	79
210	1 1 0 1 0 0 1 0	X'	0	X	Y	Z'	Y'	Z	1	X+YZ+Z	26
211	1 1 0 1 0 0 1 1	X	Y	Y'	X'	0	1	Z'	0	XYZ+XY+XZ+Y+1	229
212	1 1 0 1 0 1 0 0	X'	X	0	0	X	Y	Z'	0	XY+XZ+X+YZ+Y	124
213	1 1 0 1 0 1 0 1	X	Y	1	Z'	0	0	0	0	XYZ+Z+1	131
214	1 1 0 1 0 1 1 0	X	Z'	0	X'	Z'	Y	Z	Y'	XYZ+XY+X+Y+Z	214
215	1 1 0 1 0 1 1 1	X'	Y'	Y	0	X	X'	Z'	X	XZ+YZ+1	41
216	1 1 0 1 1 0 0 0	X	Z'	0	X'	0	1	Y	Z	XZ+X+YZ	56
217	1 1 0 1 1 0 0 1	Y	X	Z'	Y'	0	1	Z	0	XYZ+XY+Y+Z+1	199
218	1 1 0 1 1 0 1 0	X	Y	Z	X'	0	1	Z'	0	XYZ+X+Z	146
219	1 1 0 1 1 0 1 1	X	Y	Y'	X'	0	Z'	1	Z	XY+XZ+YZ+Y+1	109
220	1 1 0 1 1 1 0 0	Y	1	X	Z'	0	0	0	0	XYZ+XY+XZ+X+Y	244
221	1 1 0 1 1 1 0 1	Y	1	1	Z'	0	0	0	0	YZ+Z+1	11
222	1 1 0 1 1 1 1 0	X	Z'	Z	X'	0	X	Y	X'	XY+X+YZ+Y+Z	94
223	1 1 0 1 1 1 1 1	X'	1	1	Z'	Y	0	1	0	XYZ+XZ+1	161
224	1 1 1 0 0 0 0 0	Y	0	0	Z	0	1	X	1	XYZ+XY+XZ	224
225	1 1 1 0 0 0 0 1	X	Z	Z'	0	X'	Y	X	Y'	X+YZ+Y+Z+1	31
226	1 1 1 0 0 0 1 0	X	Y	0	X'	0	1	Z	Y'	XY+YZ+Z	74
227	1 1 1 0 0 0 1 1	X	Y	Y'	X'	0	1	Z	0	XYZ+XZ+X+Y+1	181
228	1 1 1 0 0 1 0 0	X	Z	0	X'	0	1	Y	Z'	XZ+YZ+Y	44
229	1 1 1 0 0 1 0 1	X'	Z'	Y	0	X	0	Z	1	XYZ+XY+X+Z+1	211
230	1 1 1 0 0 1 1 0	X	Y	Y'	Z	Z'	1	0	0	XYZ+Y+Z	134
231	1 1 1 0 0 1 1 1	X	Z	Z'	X'	0	Y	1	Y'	XY+XZ+X+YZ+1	121
232	1 1 1 0 1 0 0 0	X	Y	0	X'	0	X	Z	Y	XY+XZ+YZ	104
233	1 1 1 0 1 0 0 1	X	Z	Z'	0	X'	Y	X	Y'	XYZ+X+Y+Z+1	151
234	1 1 1 0 1 0 1 0	X	Y	1	Z	0	0	0	0	XYZ+XY+Z	194
235	1 1 1 0 1 0 1 1	X	Y	Y'	X'	0	X	Z	X'	XZ+X+YZ+Y+1	61
236	1 1 1 0 1 1 0 0	X	Z	1	Y	0	0	0	0	XYZ+XZ+Y	164
237	1 1 1 0 1 1 0 1	Z	Y	Y	Z'	0	X	Y'	X'	XY+X+YZ+Z+1	91
238	1 1 1 0 1 1 1 0	Y	1	1	Z	0	0	0	0	YZ+Y+Z	14
239	1 1 1 0 1 1 1 1	X'	1	1	Z	Y	0	1	0	XYZ+XY+XZ+X+1	241
240	1 1 1 1 0 0 0 0	X	1	0	0	0	0	0	0	X	16
241	1 1 1 1 0 0 0 1	X	1	Y'	Z'	0	0	0	0	XYZ+XY+XZ+YZ+Y+Z+1	239
242	1 1 1 1 0 0 1 0	X	1	Y'	Z	0	0	0	0	XYZ+XZ+X+YZ+Z	186
243	1 1 1 1 0 0 1 1	X	1	1	Y'	0	0	0	0	XY+Y+1	69
244	1 1 1 1 0 1 0 0	X	1	Z'	Y	0	0	0	0	XYZ+XY+X+YZ+Y	220
245	1 1 1 1 0 1 0 1	X	1	1	Z'	0	0	0	0	XZ+Z+1	35
246	1 1 1 1 0 1 1 0	X	1	Z	Y'	Y	0	Z'	0	XY+XZ+X+Y+Z	118
247	1 1 1 1 0 1 1 1	X	1	1	Z'	Y'	0	1	0	XYZ+YZ+1	137
248	1 1 1 1 1 0 0 0	X	1	Z	Y	0	0	0	0	XYZ+YZ+X	152
249	1 1 1 1 1 0 0 1	X	1	Z'	Y'	0	0	Z	0	XY+XZ+Y+Z+1	103
250	1 1 1 1 1 0 1 0	X	1	1	Z	0	0	0	0	XZ+X+Z	50
251	1 1 1 1 1 0 1 1	X	1	1	Z	Y'	0	1	0	XYZ+XY+YZ+Y+1	205
252	1 1 1 1 1 1 0 0	X	1	1	Y	0	0	0	0	XY+X+Y	84
253	1 1 1 1 1 1 0 1	X	1	1	Z'	Y	0	1	0	XYZ+XZ+YZ+Z+1	171
254	1 1 1 1 1 1 1 0	X	1	1	Z	Y	0	1	0	XYZ+XY+XZ+X+YZ+Y+Z	254
255	1 1 1 1 1 1 1 1	1	1	0	0	0	0	0	0	1	1

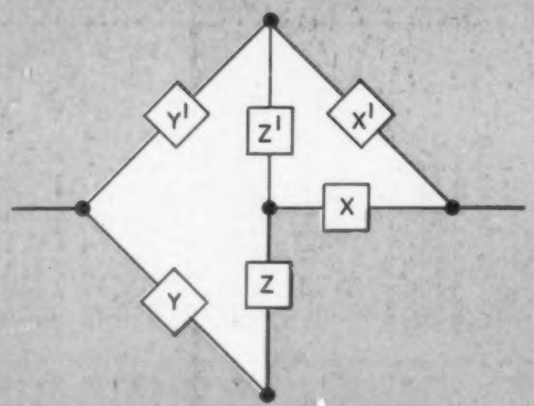


Fig. 3—Circuit for XZ + Y + 1, which has test number 147 in Table 1. Primes denote complementary relays (X' is off when X is on, X' is on when X is off)

to convert 1101 the process is as follows:

1	1	
1	Dabble	$1 \times 2 + 1 = 3$
0	Double	$3 \times 2 = 6$
1	Dabble	$6 \times 2 + 1 = 13$

Or 1101 in the binary system is 13 in the decimal system.

To convert decimal numbers to binary numbers the foregoing "doubling and dabbling" process can be reversed. The terms "rouble" and "rabble" have been coined to describe the reversing of double and dabble, respectively. If a number is even, rouble it by dividing by 2. If a number is odd, rabble it by subtracting 1 and then dividing by 2. For example, to convert the decimal number 13 proceed as follows

Rabble	$\frac{1}{2}(13-1)$	$= 6$
Rouble	$\frac{1}{2}(6)$	$= 3$
Rabble	$\frac{1}{2}(3-1)$	$= 1$
Rabble	$\frac{1}{2}(1-1)$	$= 0$

the process being repeated until the final result is zero. The recording process consists of writing down in reverse a 1 for every rabble and a 0 for every rouble, thus: 1101. With practice the recording can be done simultaneously with the mental roubling and rabbling.

In the following analysis of three-relay systems, eight-place binary numbers will be used for organizing the table of 256 circuits and for use with the matrices which convert desired relay responses to the formula for the relay circuit.

Binary Matrices: A matrix is a rectangular array of numbers. The product of two matrices is formed by multiplying the numbers in the *rows* of the first matrix by the corresponding numbers in the *columns* of the second matrix and adding the individual products. In order to be multiplied together, the first matrix must have as many columns as the second matrix has rows. In the decimal system, two matrices may thus be multiplied as follows:

$$[1\,3\,2]\begin{bmatrix}1&2&6\\3&1&1\\2&1&2\end{bmatrix} = [1\times1+3\times3+2\times2 \quad 1\times2+3\times1+2\times1 \quad 1\times6+3\times1+2\times2] \quad \text{.......(1)}$$

The product may simply be written [14 7 13]. Matrices are extremely useful in statistical, electrical and mechanical problems,[2] because they make it possible to handle a great number of equations simultaneously.

A binary matrix is a matrix whose numbers are either 0 or 1. In the following discussion odd-even algebra will be used in multiplying binary matrices so that the multiplications become very easy:

$$[1\,0\,1\,1]\begin{bmatrix}1&0&0&0\\1&1&0&0\\1&0&1&0\\1&1&1&1\end{bmatrix} = [1\times1+0\times1+1\times1+1\times1 \quad 1\times0+0\times1+1\times0+1\times1 \quad 1\times0+0\times0+1\times1+1\times1 \quad 1\times0+0\times0+1\times0+1\times1] \quad \text{..(2)}$$

The product is quickly reduced by odd-even algebra to [1 1 0 1]. There may be algebraic symbols in the matrices. The product of the foregoing two matrices (Equation 2) may now be multiplied by a matrix having one column of variables:

$$[1\,1\,0\,1]\begin{bmatrix}YZ\\Y\\Z\\1\end{bmatrix} = YZ + Y + 1 \quad \text{..................(3)}$$

Combining the two previous multiplications, a product of three matrices can be written:

$$[1\,0\,1\,1]\begin{bmatrix}1&0&0&0\\1&1&0&0\\1&0&1&0\\1&1&1&1\end{bmatrix}\begin{bmatrix}YZ\\Y\\Z\\1\end{bmatrix} = YZ + Y + 1 \quad \text{.........(4)}$$

Table of Three-Relay Circuits: For circuits containing, at most, three independent relays there will be 256 possible results when the individual relays are placed in their eight possible conditions, ranging from all *on* to all *off*. These 256 results may be expressed as binary numbers ranging from 00000000 to 11111111, or in the decimal system from 0 to 255. In Table 1 the number which tells how a circuit responds to the eight conditions of the individual relays is called the *test number* of the circuit and is represented by *T*.

The binary test number of a circuit gives the circuit response to these eight combinations of the individual relays in the left-to-right order as shown:

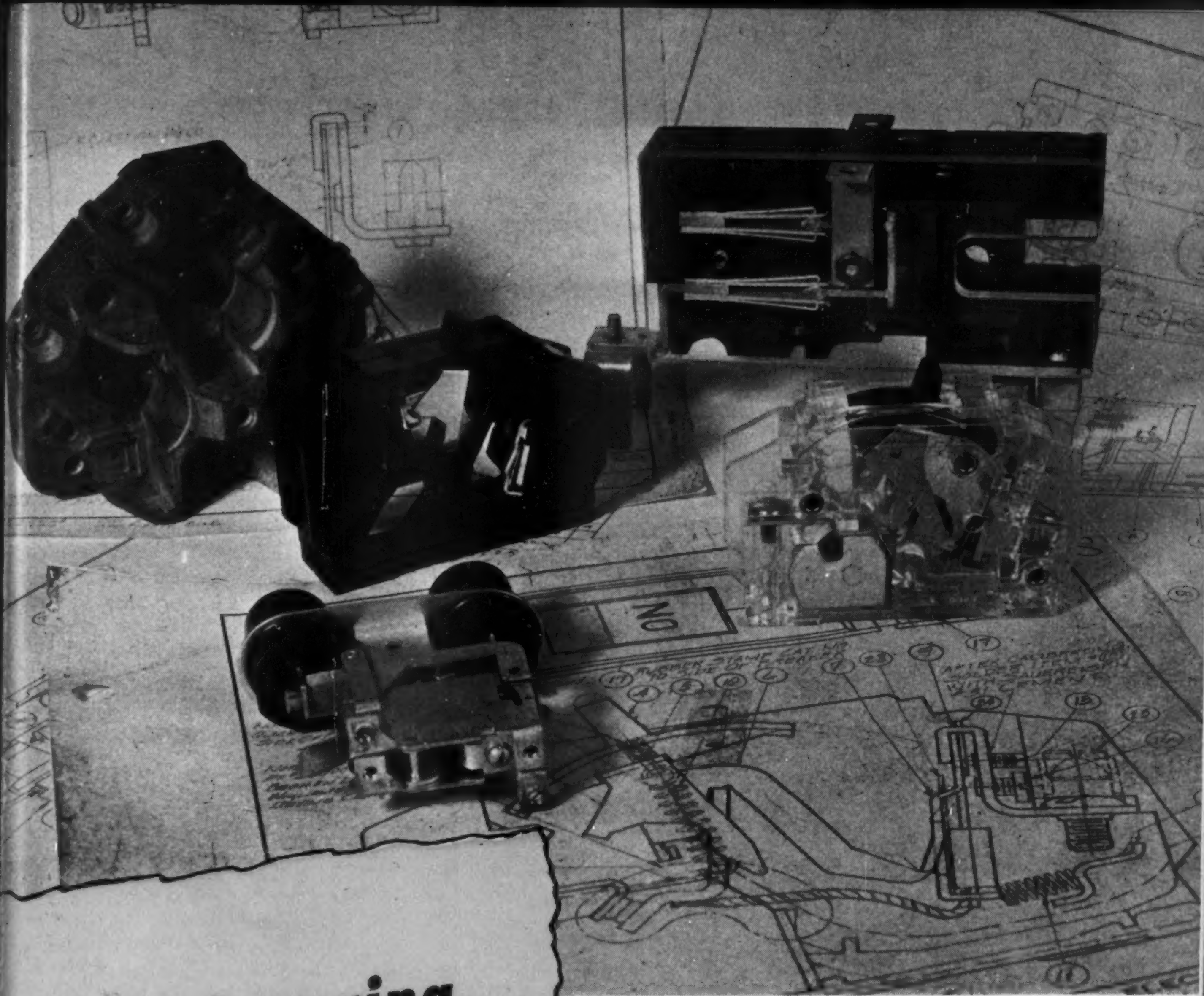
X on	*X* on	*X* on	*X* on	*X* off	*X* off	*X* off	*X* off
Y on	*Y* on	*Y* off	*Y* off	*Y* on	*Y* on	*Y* off	*Y* off
Z on	*Z* off	*Z* on	*Z* off	*Z* on	*Z* off	*Z* on	*Z* off

For example, a circuit whose test number is 32 has a binary test number of 00100000 which means that the circuit is *on* when *X* is *on*, *Y* is *off* and *Z* is *on* and that the circuit is *off* for the other seven combinations of *X*, *Y* and *Z*.

Each circuit has a *formula* which is listed in Table 1. When the values of the individual relays (0 or 1) are substituted into the formula and its value is calculated by using odd-even algebra the condition of the entire circuit is *off* for a calculated 0 or is *on* for a calculated 1. Each formula has a unique *formula number*, denoted by *F*, which is obtained by letting $X = 16$, $Y = 4$, $Z = 2$, and using ordinary algebra to combine the values of the terms. The *F* for each circuit is given in the table.

Each circuit in Table 1 can be wired by placing relays in an eight-position master network shown in *Fig.* 1. This master network is a square with both diagonals drawn and joined at their midpoints. Re-

(*Continued on Page* 192)



Engineering Good Patents

Adequate arrangements and policy by engineering management are vital in laying the groundwork for good patents

By Robert T. Casey
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Fig. 1—Part of the groundwork for good patent operations includes the preparation of useful supplementary material in connection with disclosures. At the back, left, is a wooden model; back, right, is a working model; center, left, is a cutaway breaker model to expose the mechanism; center, right, is a breaker model with transparent housing; and front is a production sample switch mechanism

SUCCESSFUL handling of all patent matters must start at home—with engineers, inventors, and key management personnel. Their activities form the base for what is broadly referred to as "the patent situation." The great majority of small and medium-size manufacturing companies, however, do not or cannot employ a full-time patent attorney at the plant. Often the attorney is located in New York or in Washington, many miles from the working place of designers and far from the offices of management.

In these companies, it is highly desirable that

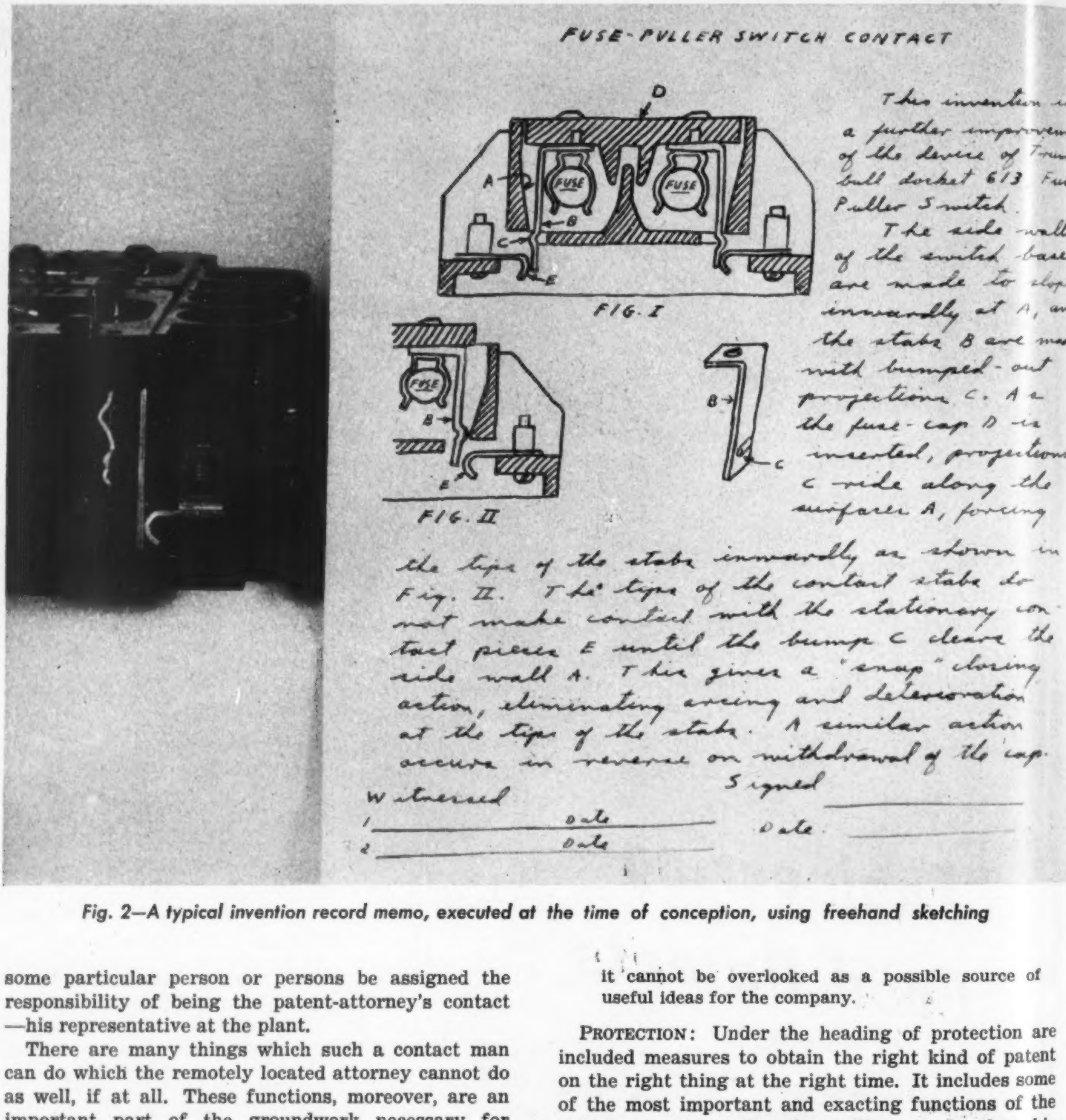


Fig. 2—A typical invention record memo, executed at the time of conception, using freehand sketching

some particular person or persons be assigned the responsibility of being the patent-attorney's contact —his representative at the plant.

There are many things which such a contact man can do which the remotely located attorney cannot do as well, if at all. These functions, moreover, are an important part of the groundwork necessary for good patents, and for a good "patent policy," *Fig.* 1. These functions may be conveniently classified under three main headings which apply to corporate patent matters generally. These are:

1. *Protection.* Patents afford protection for the original designs and developments produced by the company. Trademarks and copyrights afford protection for other valuable company property
2. *Regard for others' patents.* The patents of others must be considered as to their bearing on the designs and processes employed at the plant. They may also offer opportunity, through purchase or licensing, to manufacture of profitable items
3. *Employee and public relations.* Intelligent and honest handling of submitted ideas is a "must" for safety reasons. It also affords opportunity for fostering good employee and public relations. And it cannot be overlooked as a possible source of useful ideas for the company.

PROTECTION: Under the heading of protection are included measures to obtain the right kind of patent on the right thing at the right time. It includes some of the most important and exacting functions of the patent contact at the plant. The way he does his work will directly affect such important questions as priority of invention and the value and validity of the patent obtained.

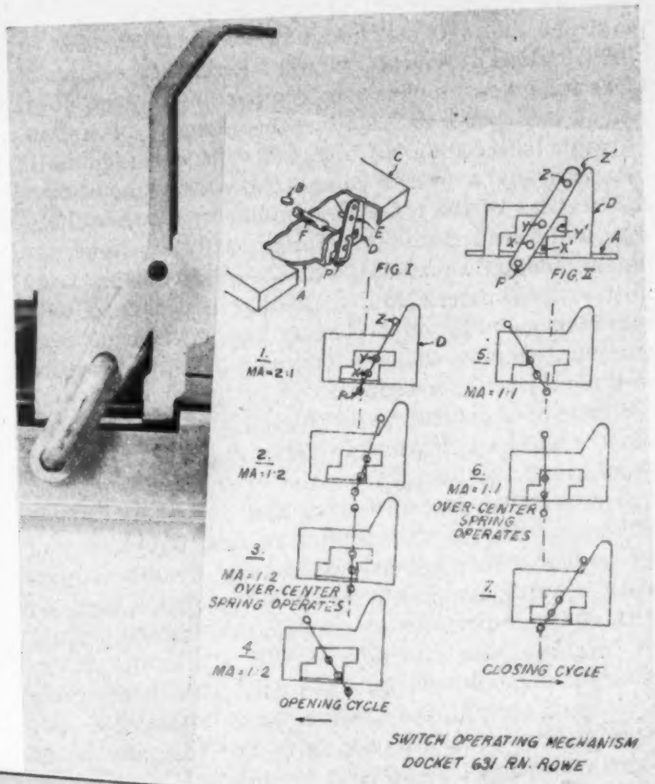
Good Records A Necessity

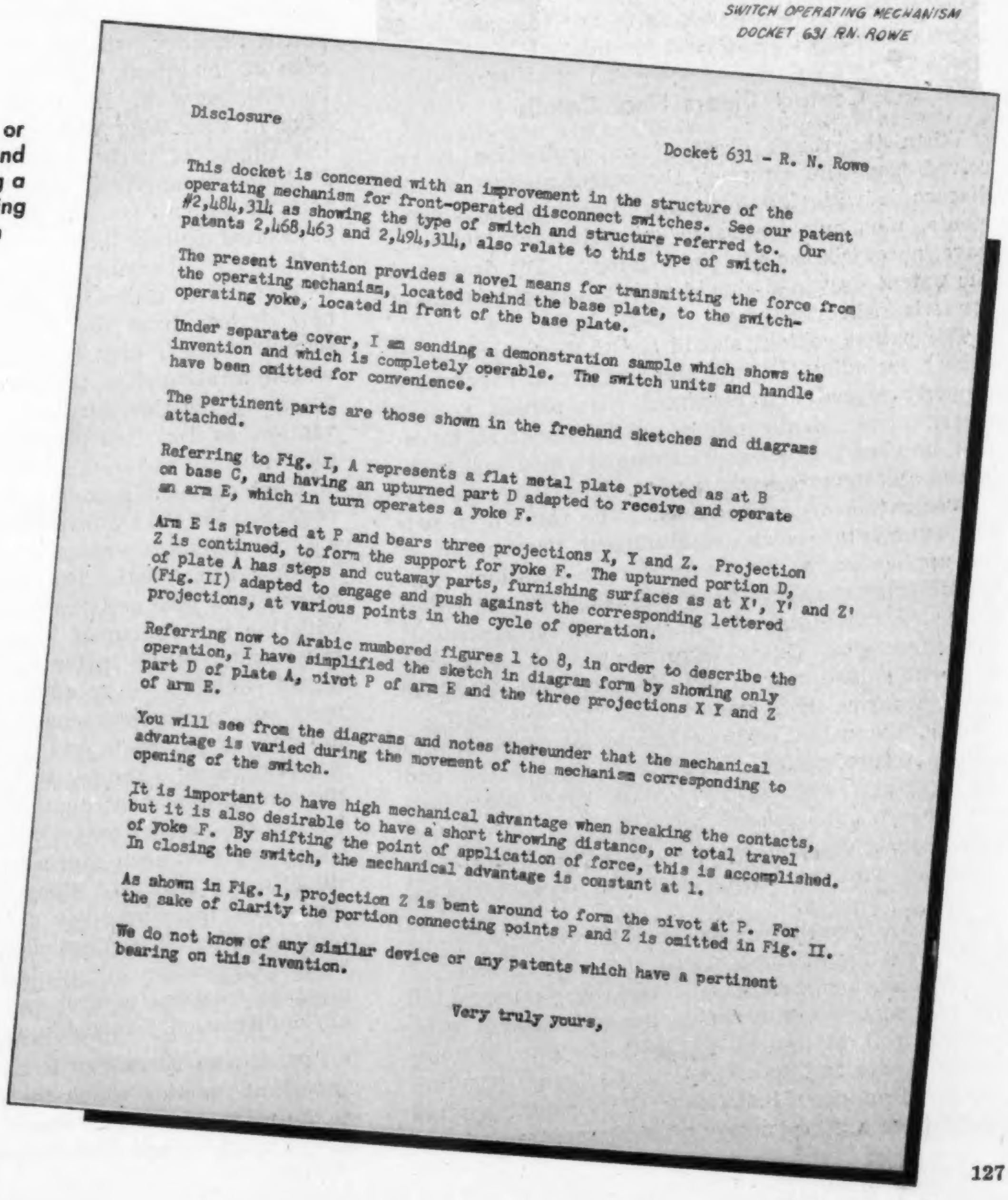
RECORDS: The patent contact should see that adequate, properly witnessed records of all development work are kept, *Fig.* 2. He may wish to keep a separate file for such developments until approved for patent application. This avoids filling "docket" files with folders which may never become applications. It also makes it more likely that records will be kept of all developments, even though they may not initially give promise of rising to the dignity of a patent application.

He should keep in close touch with engineers and designers at all times. This is the only practical way to see that the proper records are made. Too, he should continue to follow developments even after the filing of the patent application. As devices are put into production, changes are frequently made which affect the desired wording of claims, or make the filing of an additional application advisable.

Patentability Advice: The patent contact should make or obtain "novelty searches" as required. These consist of search of related issued patents, technical magazines, books and other similar sources. Personal knowledge of company engineers should not be overlooked. Advice can then be given as to the probable patentability of each design.

Usually such a novelty search must be obtained from the patent attorney or other searcher not located at the plant. The patent contact in such cases must prepare or have the inventor prepare under his guidance, a complete, understandable disclosure of the invention. This should include some of the technical background of the development, and





Disclosure

Docket 631 - R. N. Rowe

This docket is concerned with an improvement in the structure of the operating mechanism for front-operated disconnect switches. See our patent #2,484,314 as showing the type of switch and structure referred to. Our patents 2,468,463 and 2,494,314, also relate to this type of switch.

The present invention provides a novel means for transmitting the force from the operating mechanism, located behind the base plate, to the switch-operating yoke, located in front of the base plate.

Under separate cover, I am sending a demonstration sample which shows the invention and which is completely operable. The switch units and handle have been omitted for convenience.

The pertinent parts are those shown in the freehand sketches and diagrams attached.

Referring to Fig. I, A represents a flat metal plate pivoted as at B on base C, and having an upturned part D adapted to receive and operate an arm E, which in turn operates a yoke F.

Arm E is pivoted at P and bears three projections X, Y and Z. Projection Z is continued, to form the support for yoke F. The upturned portion D, of plate A has steps and cutaway parts, furnishing surfaces as at X', Y' and Z' (Fig. II) adapted to engage and push against the corresponding lettered projections, at various points in the cycle of operation.

Referring now to Arabic numbered figures 1 to 8, in order to describe the operation, I have simplified the sketch in diagram form by showing only part D of plate A, pivot P of arm E and the three projections X Y and Z of arm E.

You will see from the diagrams and notes thereunder that the mechanical advantage is varied during the movement of the mechanism corresponding to opening of the switch.

It is important to have high mechanical advantage when breaking the contacts, but it is also desirable to have a short throwing distance, or total travel of yoke F. By shifting the point of application of force, this is accomplished. In closing the switch, the mechanical advantage is constant at 1.

As shown in Fig. 1, projection Z is bent around to form the pivot at P. For the sake of clarity the portion connecting points P and Z is omitted in Fig. II.

We do not know of any similar device or any patents which have a pertinent bearing on this invention.

Very truly yours,

Fig. 3—Sample write-up or "disclosure," with freehand sketches, used in requesting a novelty search or in drawing up a patent application

point out the features thought to be new, *Fig.* 3.

Evaluation of Inventions: The careful screening of ideas for patent application is important to keep down patent costs and to improve the chances of an application succeeding as a patent. This screening is best done by a patent committee, consisting of representatives of the research, engineering, and marketing divisions. Both the patent attorney and the patent contact should also be members of this committee. The patent contact should be charged with the responsibility of preparing the agenda of each meeting, keeping the minutes, and of calling special meetings when necessary.

Filing of Applications: To enable the attorney to draw up the application properly, the patent contact should make or obtain from the inventor, a complete, understandable description of the device concerned. This may include standard drawings, supplemented by freehand sketches and photographs. Where possible, working samples, disassembled samples, samples with cutaway portions or transparent casings, should be furnished the attorney, *Fig.* 1. In addition, the disclosure should include a comparison with prior devices or competitive devices where applicable, and refer to any previous patents of the company or of competitors which are closely related.

Contact Clears Final Details

When the rough draft of an application is received from the attorney, the patent contact should discuss it with the inventor. The inventor's comments, plus any comments the patent contact may have, should be sent to the attorney. The draft and the patent drawings should also be checked carefully for technical correctness.

The patent contact should see that all application papers, including the oath and assignment papers, are properly signed and notarized. He should keep a record of all dates of sale or publication of an invention, and see that all applications are filed well within the statutory one-year period.

Prosecution of Applications: The value of a patent depends as much on intelligent prosecution of the application as on its proper preparation. The patent contact should look over each Patent Office action on the case, and copies of the reference patents cited by the Office. Wherever possible, he should comment on the action, and where advisable, include comments from the inventor.

Often the patent contact or the inventor can see an important distinction between the application and the references which the patent attorney is not in a position to appreciate without such assistance. Amendments prepared by the attorney should also be reviewed, with particular attention to newly added claims.

In the infrequent cases where interferences arise involving company applications, the assistance of the patent contact is indispensable to proper prosecution. The particular ways in which this assistance is to be rendered will, of course, vary with the case, and are too numerous and specialized to be listed in detail.

Other Protection Functions: The patent contact should have a good knowledge of the nature and coverage of all company-owned patents. He should keep himself aware in a general way of new products in the company's field so as to notice and investigate possible infringements. He must be ready to assist the attorney in negotiations or litigation regarding infringements and licenses negotiated under company patents.

The patent contact's duties will also include assistance to the attorney in obtaining and protecting trademarks. The value of a trademark depends largely on its proper continued usage. The patent contact, located at the plant, is in a particularly suitable position to correct abuses of a trademark at their source.

REGARD FOR OTHER'S PATENTS: It is of utmost importance to any manufacturer to have some reliable assurance that a new product he proposes to manufacture does not constitute an infringement of another's valid patent. Opinions on which a manufacturer stakes his decision, involving usually many thousands of dollars investment, should of course be rendered by a competent patent attorney.

Patent Approval of New Devices: The patent contact, by reason of his work and association with the patent attorney, will naturally come to have knowledge of important unexpired patents which have to be reckoned with. He should make use of this knowledge in consulting with engineers and designers in the course of early development of new products. Preliminary approval searches by the patent contact, of patents kept on file at the plant, can often save great expense later.

It is an important function of the patent contact to obtain the necessary patent approval opinion on new devices from the attorney. An "infringement search" (which may be combined with the novelty search mentioned in the foregoing) will usually be necessary for this purpose. A disclosure of the invention, as described previously, will be needed here too. Reports received giving results of such novelty and infringement searches should be referred to the engineers for their information and should be kept on file for convenient reference.

Other Functions: The patent contact should be prepared to give assistance and advice in connection with the negotiation of licenses which the company takes under others' patents. It will probably be the patent contact's job to advise the accounting department as to royalty reporting, including time and amounts of payments and devices involved.

Infringement charges, which may be received by the company, present another situation in which the help of the patent contact can be of great value. He should see that such charges are referred to the patent attorney promptly, along with sufficient information about the company's devices involved. If necessary, the patent contact should do the required legwork to assemble all available information at the plant as to dates of first sale of the device, "prior art" information, personal knowledge of engineers, etc.

PUBLIC AND EMPLOYEE RELATIONS: An extremely important function which the patent contact, located at the plant, has to perform, is to see that ideas submitted to the company by outsiders are properly han-

dled. This is important if unpleasant misunderstandings and costly lawsuits are to be avoided.

Public Relations: Since it involves one of the few ways in which the public comes in direct contact with the company, other than as a buyer of its products, the handling of submitted ideas can also be an important factor affecting public opinion toward the company.

The patent contact should see that company personnel who are likely to receive such submittals are advised how to handle them. The usual practice would be to have such submittals forwarded without comment to the patent contact for further handling. The patent contact may then acknowledge the submittal and refer it to the patent attorney. If handling them directly, he may acknowledge the submittal and at the same time advise the submitter of company policies in such matters.

A request may be included that the submitter, if he wishes to have his idea considered, sign a statement to the effect that he understands the company's policies, and is willing to have his idea considered on this basis. The idea may then be referred to proper company personnel for consideration, and a prompt report made by the patent contact or the patent attorney to the submitter as to the company's decision.

Employee Relations: The handling of patent aspects of employee inventions and suggestions can be an important factor affecting employee relations and morale. It goes without saying that the patent contact must become well-informed on these subjects and be able to answer or obtain an answer for all employee questions on the subject.

It is the policy in many companies to ask certain employees such as engineers, designers, or other personnel, to execute agreements to assign inventions in the company's field. The patent contact should be made responsible for seeing that this is done, and that such agreements are kept up to date and changes made in accordance with changes in personnel.

The patent contact should also see that employee-submitted ideas not governed by an assignment agreement are properly handled. This usually means to see that the employee clearly understands the basis on which the submittal is to be considered, and that a properly witnessed and dated disclosure is obtained. This may be referred with any pertinent comment to the proper company personnel, including the patent attorney, for consideration.

The patent contact should, among other miscellaneous duties, look through the *Official Gazette* each week and order copies of patents which appear to be of interest to the company. Some or all of these may be referred to the engineers or designers working in related fields. *The Journal of the Patent Office Society* and the *United States Patents Quarterly* publications also hold material of great value to the patent contact.

CONCLUSION: The company which does not employ a full-time patent attorney at the plant is under somewhat of a handicap in any case. Such companies will usually find that it will pay well in the long run to have a patent contact to handle the jobs outlined in the foregoing.

Patents are big business. They can mean life or death to a company. They require, and deserve, a considerable outlay of money. This substantial investment will, with the assistance of an able patent contact, be found to produce much more gratifying results in patent protection, security of position with regard for others' patents, and good employee and public relations.

Mobile Lab Makes Twenty-Four Measurements

A 12-TON mobile measurements laboratory containing electronic instruments for minute scientific measurements has been built for the Army Ordnance Department after a year and a half of research and development by Armour Research Foundation.

The trailer laboratory can make 24 stress, temperature, speed, pressure, or motion measurements simultaneously. More than five miles of cable were necessary for electrical connections and to permit setting the trailer at sufficient distances from explosions.

It is estimated that an able mathematician would take two years to analyze the data that can be collected by this laboratory in one week. Six high-speed cameras running simultaneously in the mobile oscillographic unit take pictures of 24 cathode ray tubes which measure the various quantities.

Specific tests which the laboratory can perform are riding qualities of vehicles, pressures set up by discharge of explosives, the resistance of structures to air blast and underground shock, etc.

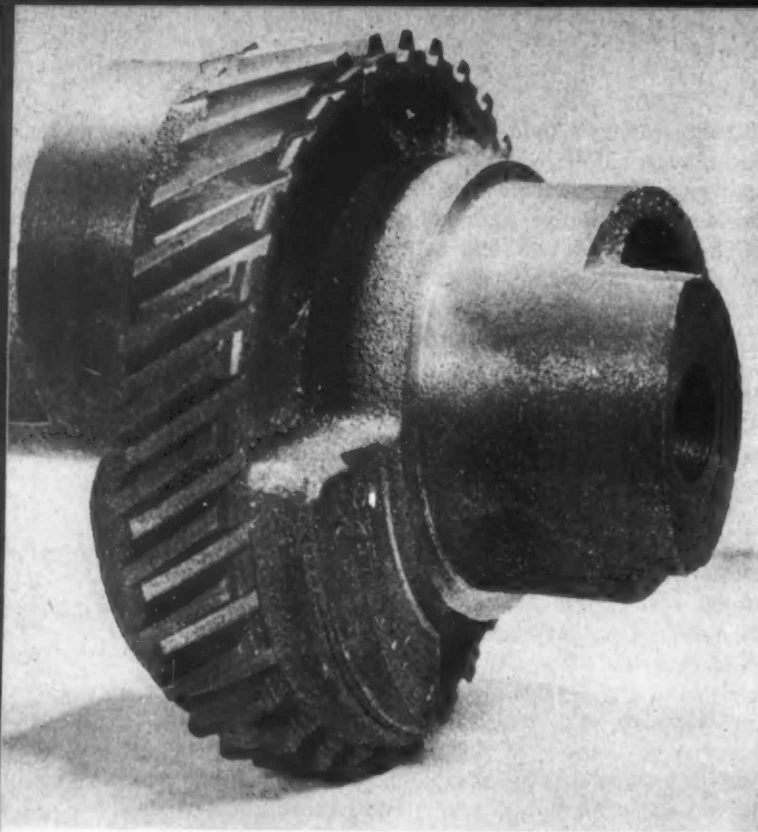


Fig. 1—A Meehanite pressure pump worm gear with eccentrics exhibiting a variety of complex sections

Section Thickness

. . . its influenc

By C. R. Austin
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IT IS well known that special foundry techniques are necessary in order to maintain daily production of castings to property specifications in widely varying casting sections and also to assure essential uniformity of properties throughout any given cast section, *Fig.* 1. Attention to these two factors is basic in the production of Meehanite castings by control of charge, melting conditions, constitution and processing of the iron.

A summary of the more important physical properties of the engineering type Meehanite metals is given in TABLE 1. The mechanical properties shown in the specifications refer to the standard 1.2-inch diameter test bar and are indicative of properties obtained in castings of approximately 1-inch section. It is significant, however, that the engineer be assured of the desired properties in the actual casting and that the foundry be fully conversant with the selection of the type Meehanite casting to meet specifications.

While this is largely a matter of foundry procedure and control, it is of importance to appreciate that such material selection is practicable. *Fig.* 2 shows the general relation of casting thickness to tensile strength of the section. It will be noted that specifications are established for the 1-inch (approximately) section. However, in heavier sections there is a gradually progressive decrease in tensile strength as a function of increasing section. The foundry selects the particular engineering type Meehanite metal according to the critical (or most important) section of the casting in terms of properties specified.

Thus a casting specified in 45,000 psi Meehanite of 1-inch section would be cast in type GB metal. For similar properties in a 3 to 3½-inch section, type GA metal would be selected whereas for much heavier sections, recourse must be made to type GM castings.

Similarly, with castings less than 1-inch section, a change in process or type metal is made as illustrated in *Fig.* 3. Thus a 45,000 psi casting of ½-inch section requires a type GC Meehanite metal.

It is through the application of precise foundry controls, inherent in the Meehanite process, that the

TABLE 1—Properties of General Engineering Types of Meehanite Metal

Meehanite Metal	Tensile Str. (psi, min)	Brinell Hardness (min. as cast)	Elastic Modulus (psi)	Transverse Str. (1.2" bar, 18" ctrs.) Load (lb)	Defl. (in)	Compr. Str. (psi)	Fatigue Str. (psi)	Impact Str. (0.8" bar) (ft-lb)	Shear Str. (psi)	Damping Cap.† (per cent)	Machinability (Dalcher*)	Specific Gravity
GM	55,000	217	22,000,000	3300-3700	0.28-0.34	200,000	25,000		55,000+	21.0	50	7.34
GA	50,000	207	20,000,000	3100-3600	0.28-0.34	175,000	22,000	25-35	48,000	24.0	48	7.31
GB	45,000	196	18,000,000	3000-3400	0.28-0.34	160,000	19,000	15-23	44,000	25.0	48	7.28
GC	40,000	192	17,000,000	2900-3300	0.26-0.34	150,000	17,500	12-20	40,000	28.0	47	7.25
GD	35,000	183	14,500,000	2600-3000	0.22-0.34	130,000	15,000	8-15	35,000	30.0	44	7.22
GE	30,000	174	12,000,000	2000-2600	0.20-0.34	120,000	13,700	6-12	30,000	32.0	38	7.16

† Energy dissipated first cycle at 20,000 psi torsional stress. * Steel castings rating = 70

Meehanite Castings

ection for uniform properties

materials engineer may design with full confidence and knowledge of properties and service performance of these iron castings.

Mass Influence: Attention must also be directed to mass influence in terms of metal uniformity or density over the entire section of a casting. Control of this quality has been designated "solidity penetration power" and refers to the ability of the foundry to pour the correct metal in any given section so that there will be property uniformity throughout the section. This is of vital significance to engineering production, and it must be recognized if the engineer is to be able to make best use of the materials at his disposal.

Lack of solidity penetration and nonuniformity of properties has been experienced by most engineers from observations of fractures and machined sections of many iron castings. In such instances the outer parts of the casting are close grained and of satisfactory hardness and tensile strength. Toward the center, however, an open or porous structure with poor physical characteristics may be encountered.

Typical examples of the control of solidity penetration power with property uniformity in Meehanite iron castings are illustrated in *Fig.* 4. It may be noted that the hardness for type GB Meehanite metal, in 6 and 10-inch sections, is essentially uniform. The hardness level however is a little below the minimum of 196 Brinell hardness included in the specifications of type GB metal in 1.2-inch diameter section. Where higher hardness and tensile values are required, the casting would be poured in either type GA or GM Meehanite, depending on service performance designated.

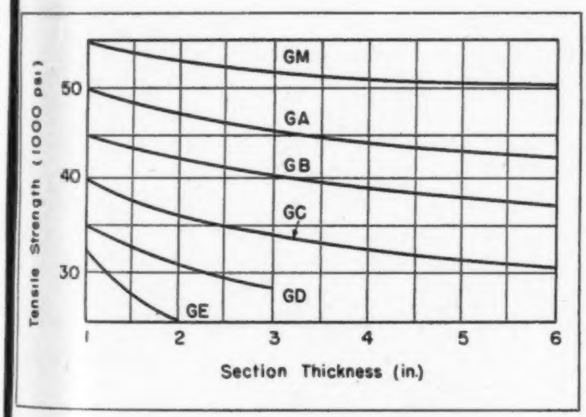
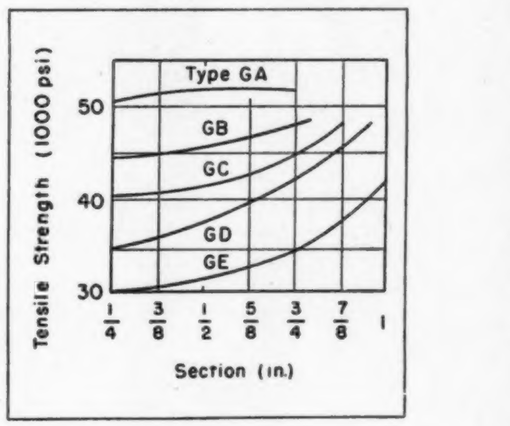


Fig. 2 — Left — Chart showing the effect of increasing section thickness on tensile strength in sections over 1 inch

Fig. 3—Right—Chart indicating the effect on tensile strength of decreasing section thickness below 1 inch



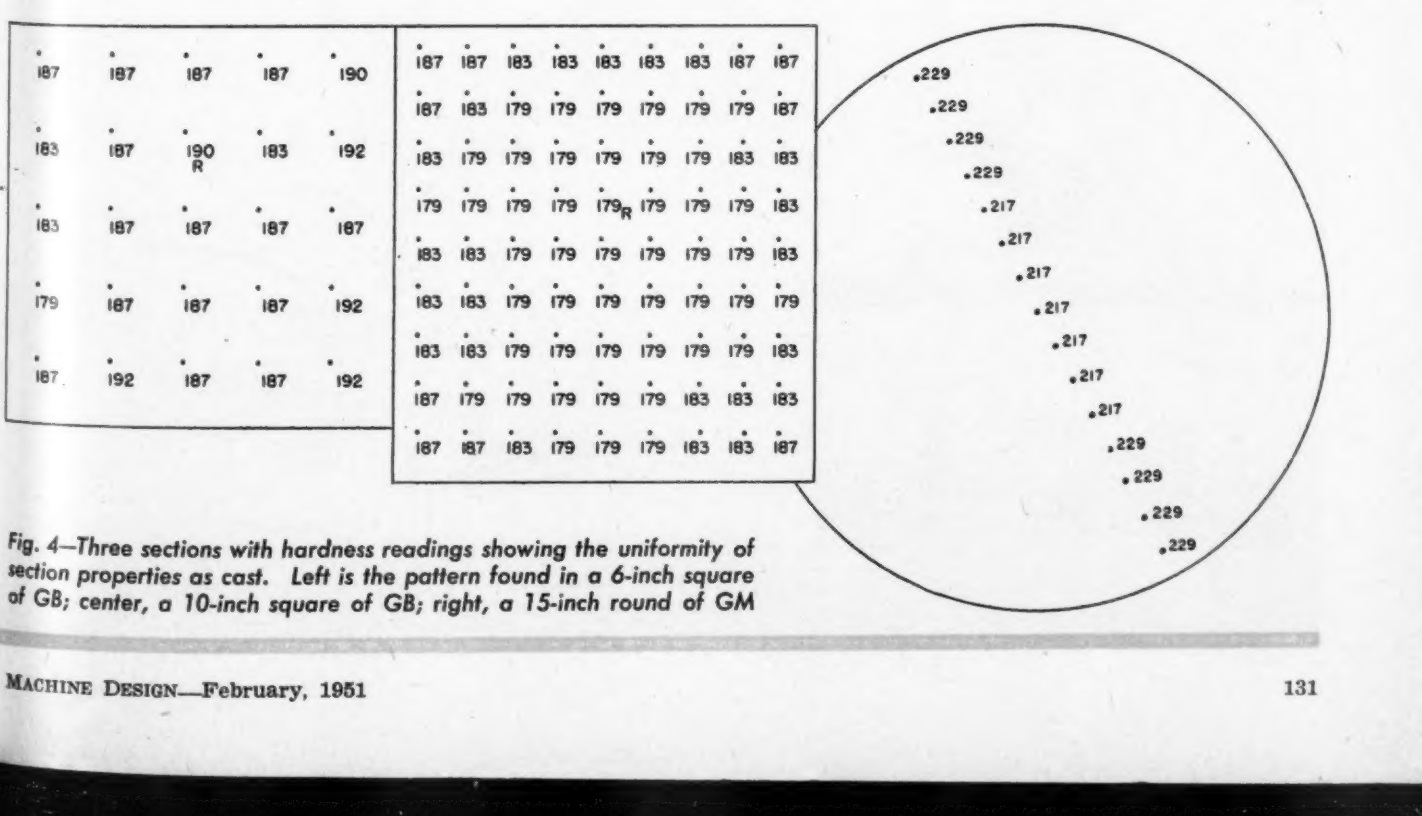
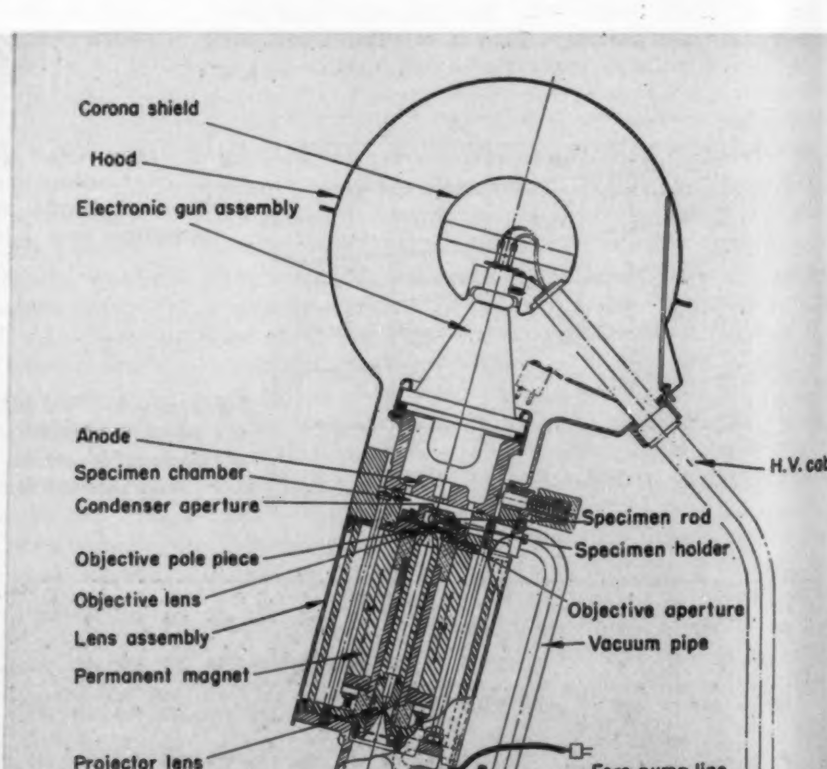


Fig. 4—Three sections with hardness readings showing the uniformity of section properties as cast. Left is the pattern found in a 6-inch square of GB; center, a 10-inch square of GB; right, a 15-inch round of GM

Contemporary

Electron Microscope Provides Increased Magnification

A SIMPLIFIED, low-cost permanent-magnet electron microscope, below, provides a 50-kv accelerating potential and a resolving power to 100 Angstrom units for laboratory and school work. With magnifications to 40,000 diameters, specimen detail as small as 0.0000004-inch is revealed. Made by Radio Corporation of America, the microscope consists of four units: the microscope proper, a control unit, high-voltage unit and vacuum pump. The drawing, below, shows the construction of the microscope which is essentially a vacuum tube arranged to permit insertion and removal of specimens. Two pumps in series are used to maintain the vacuum; a small air-cooled oil diffusion pump and a separate mechan-



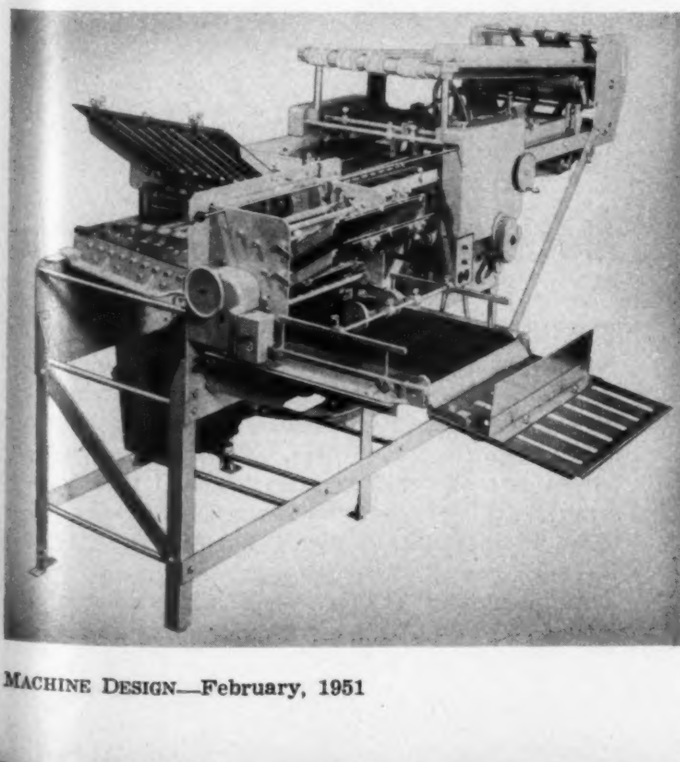
DESIGN

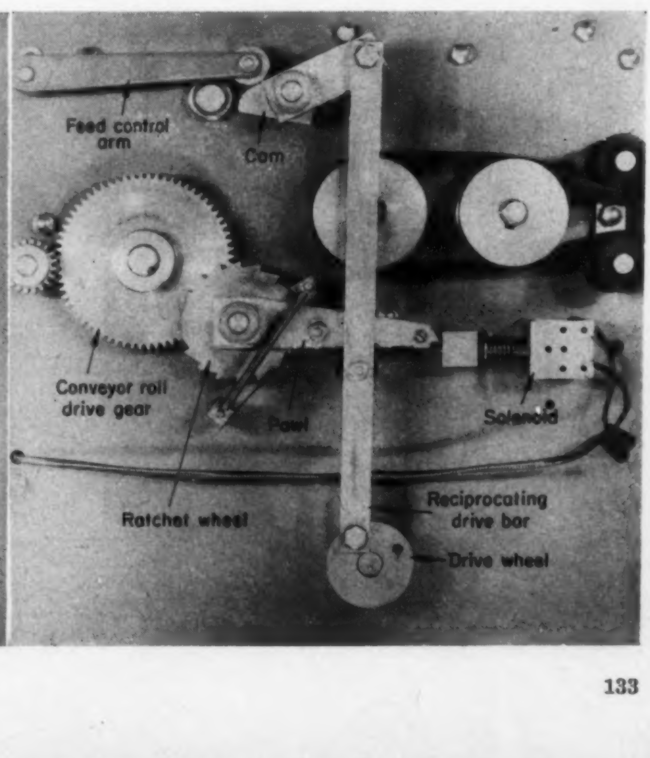
ical pump. Specimens are inserted without breaking the vacuum by means of the specimen holder shown in the drawing (bottom, previous page) with a consequent reduction in time required to photograph or observe a specimen. Specimens are introduced by withdrawing the sliding rod, inserting the specimen, and pushing the rod back in. The only loss of vacuum is that caused by the air in the small specimen cavity in the sliding rod. Similarly, plates can be changed in the camera, without destroying the vacuum, by withdrawing a viewing screen and allowing the electron beam to fall directly on the photographic plate. Operating vacuum is restored within 6 seconds after insertion of a specimen and within 1½ minutes after insertion of a plate. The permanent-magnet lens system used in the instrument makes it possible for four pounds of magnet iron to replace thousands of turns of coil wire, cables, connectors, and a three-tube electronic control circuit requiring heavy transformers.

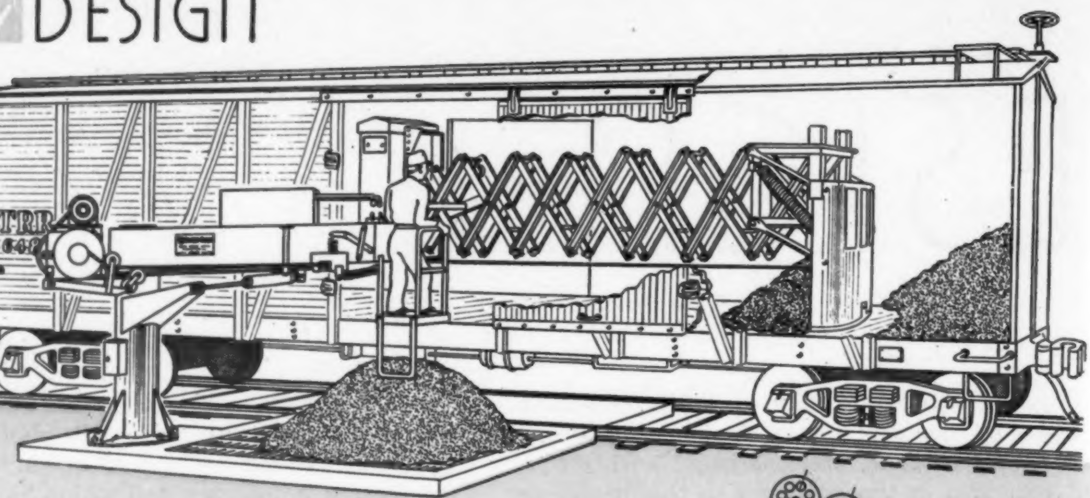
Sheets Fed Automatically on Folder

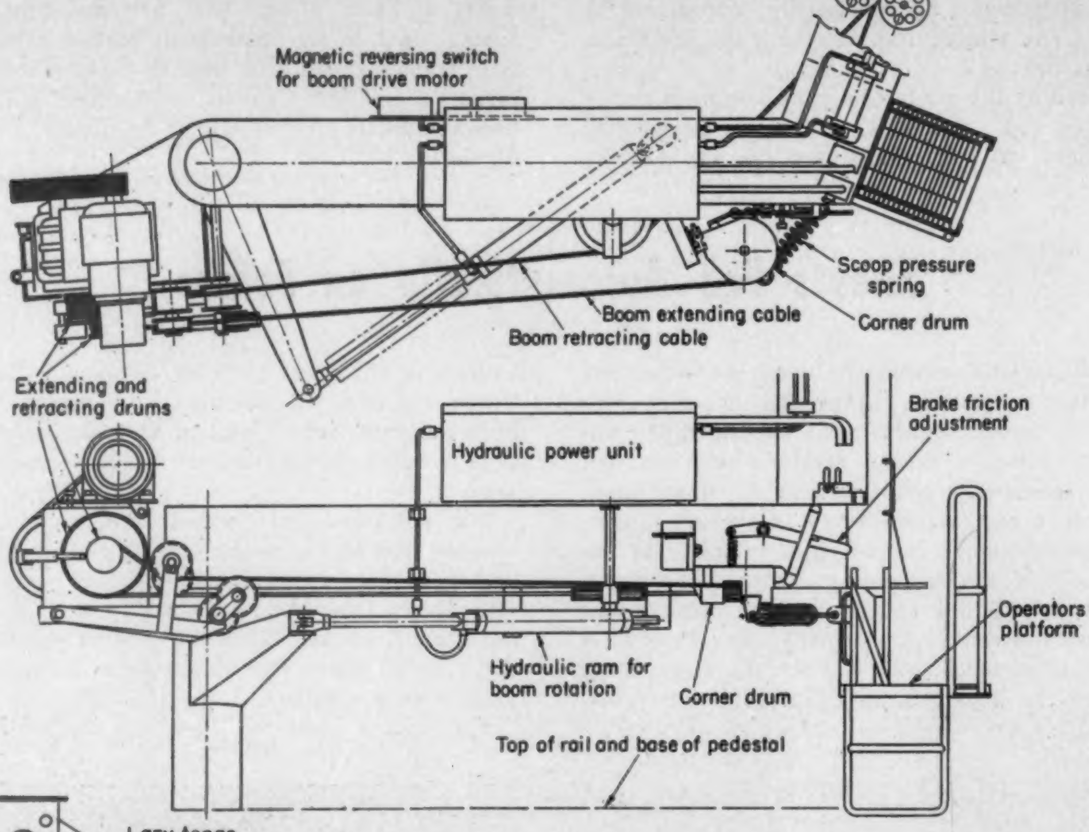
A COMPLETELY automatic, overhead-table, air-feed folding machine, below, includes a sensing roll which electrically controls the simplified pile advancing mechanism. Made by Master Folder Co., the folder uses the mechanism shown in the illustration, below, right, to regulate the speed of the infeed conveyor to provide stock in the right quantity to the suction wheel of the separating device. The reciprocating connecting link of a crank and rocker mechanism drives the conveyor roll drive gear through a pawl and ratchet mechanism. When the stock being delivered to the separator is equal to the required amount, a thickness gage wheel opens a limit switch which releases the solenoid, photograph below, to hold the pawl out of contact with the drive bar and thus prevent further driving of the conveyor drive gear.

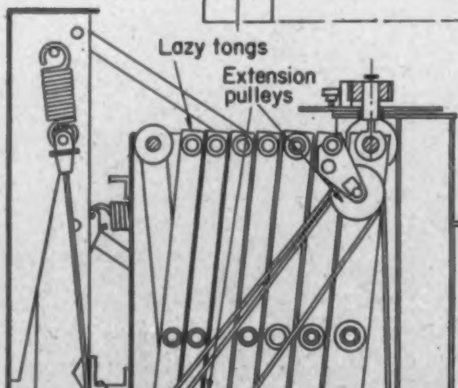
The thickness gage wheel is continuously raised and lowered on the stock of material under the separator suction wheel by a cam and a feed-control arm driven from the reciprocating bar. A set screw adjustment on the thickness control permits setting the feed within a few thousandths to accommodate various weight papers.











Machine Speeds Car Unloading

UNUSUAL boxcar unloader, top, makes handling of bulk materials safer, cheaper and cleaner than with previous power equipment. Carried on a permanently mounted pedestal, a swinging arm carries a pivoted scoop boom. The boom can be extended into the car, or retracted, and the scoop or scraper can be raised or lowered. Automatic controls in the unit, designed by Stephens-Adamson Mfg. Co., permit unloading a car in half an hour.

An interesting cable drive is used to extend and retract the boom. Drums for retracting and extend-

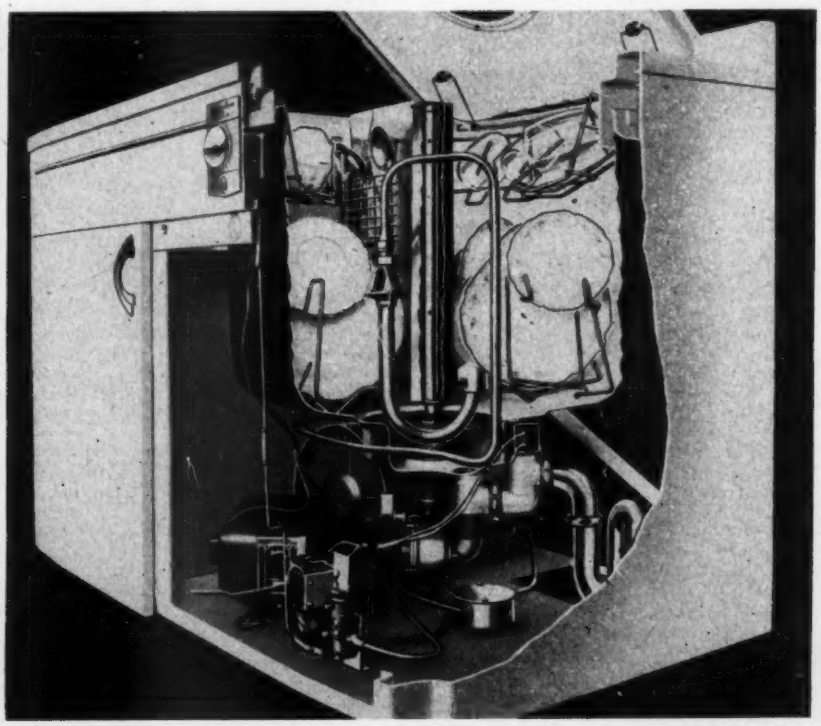
ing cables are mounted on the slow-speed shaft of a Saco speed reducer, which is driven through V-belts by a 5-hp motor. These two cables (see drawings at the left), travel in opposite directions, the extending cable coming off the top of its drum and the retracting cable off the bottom. The extending cable passes under a weighted takeup pulley and wraps around a corner drum, which pivots with its housing on the swinging arm. The cable then is reeved around a set of pulleys mounted to the boom links by supporting arms, before being anchored to one of the arms, drawing bottom, previous page. When this cable is wound up on the sheave at the reducer slow speed shaft, it pulls the pulleys mounted on the boom links together, extending the boom. When the scoop at the end of the boom meets a resistance and cable pull is increased, the corner drum and its housing tilt, tripping a limit switch that reverses the motor. A spring determines the pressure the boom scoop must exert before the limit switch will be tripped.

After the boom has extended into the car, the scoop must be lowered into the material before the boom retracts. The retracting cable also pulls the scoop down into the material, a coil spring holding the scoop up when there is no tension in the retracting cable. To be sure the scoop digs into the material before the boom retracts, the shaft on the pivoting corner drum is equipped with a brake drum. A clutch in the brake drum allows the shaft to rotate freely when the boom extending cable is being wound up (shortened). However, when the cable direction is reversed, the clutch engages, bringing the brake into play. This means that the boom cannot retract until the tension on the boom retracting cable is great enough to overcome the brake friction. Adjustment of lever arm determines brake friction and hence the force exerted by the scoop in digging down into the material. When maximum pressure is reached, the brake slips and the boom is retracted. When the boom is completely retracted, a shaft on the first link arm of the boom trips a limit switch, reversing the motor and starting a new cycle. The retracting cable is no longer under tension and cable is being paid out so the coil springs can pull the scoop back to its rest position.

The boom pivots about a fixed point on its supporting arm. This rotation is controlled by a hydraulic ram which activates a rack and pinion combination. The arm supporting the boom also pivots about the central axis of the supporting column. Another hydraulic ram controls this rotation, the ram being connected to a fixed arm at one end and the boom supporting arm at the other. Both hydraulic rams operate from separate pumps driven by a 3-hp motor.

Dishwasher Features Jet Cleaning Action

A NEW method of water distribution is among the features in the Youngstown Kitchens Jet-Tower automatic dishwasher, shown below. A square, chrome-finished tube extends through the center of the porcelain-enameled tub and is pierced with small holes placed to direct water on dishes in surrounding racks. This tube seats freely on another tube connected to a centrifugal pump. Water pumped through the inner tube causes the outer tube to spin and throw streams of water onto the dishes. Mech-

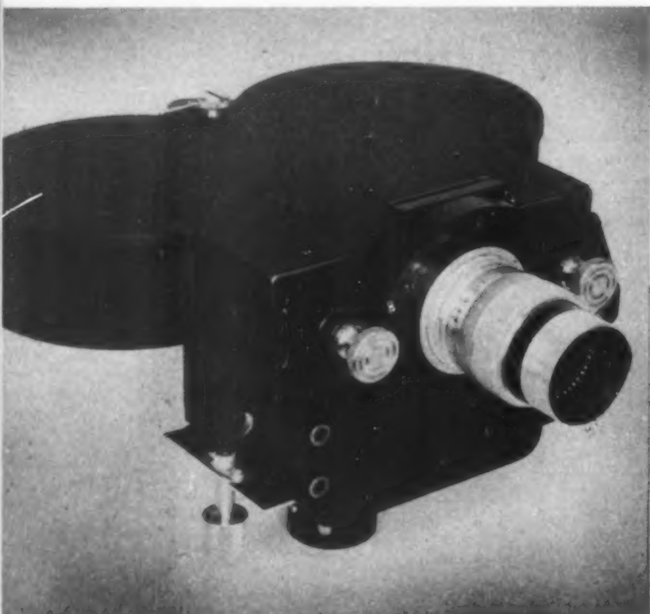


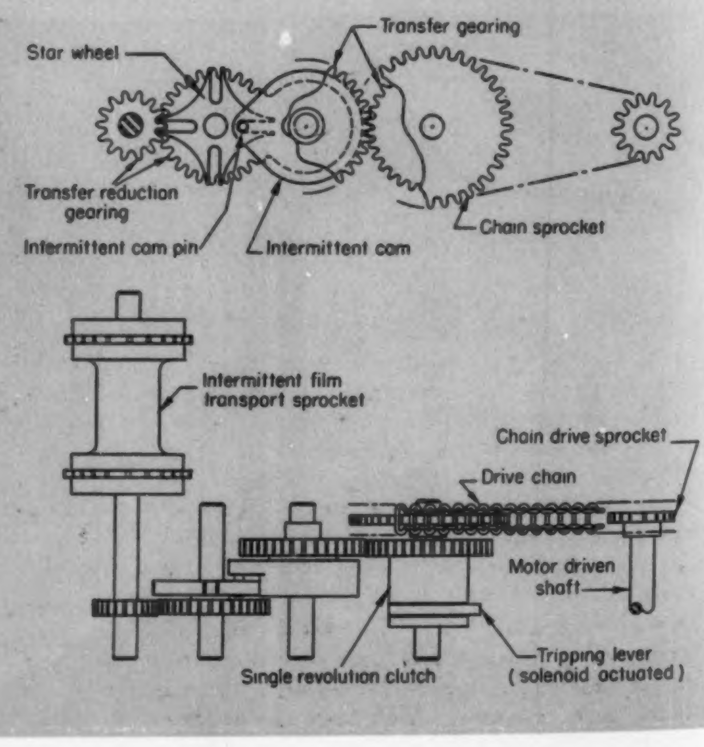
anisms of the machine shown in the cutaway view, previous page, include a timer, one-third horsepower motor, solenoid valve, and booster heater. The cycle of 9¾ minutes (with normal water pressure) is started by activating the timing mechanism and solenoid which opens to allow water to enter the tub through an antisiphon air gap. When the proper amount of water is in the tub, the motor starts driving the pump, forcing water into the upright tubes. After 2½ minutes, the pump shuts off, the tub empties and the dishes are given two rinsing cycles. The lid then automatically opens to allow the dishes to dry in their own heat. An insulated booster heater tank with 2½-gallon capacity and a 1250-watt immersion heater raise the water temperature to 180 F for better cleaning action.

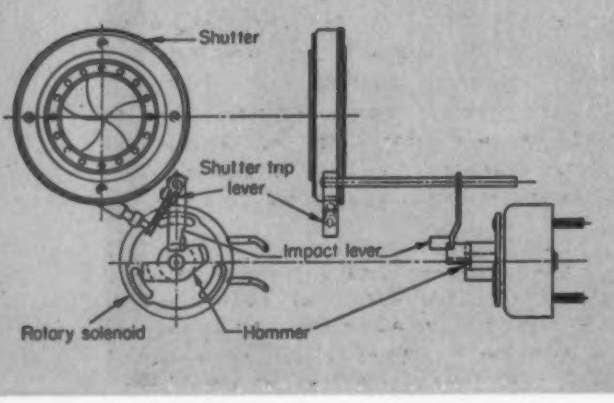
Data Camera Triggered Electrically

AN ELECTRICALLY tripped 35-mm camera, below, developed by Cook Research Laboratories, is capable of taking pictures at rates to four frames per second in airborne mapping and charting applications. An electronic flash illuminating system with a discharge duration of about 10 microseconds is triggered by a switch, located on the camera shutter, at the instant of maximum shutter opening. The shutter opening mechanism consists of a rotary solenoid, a rotary hammer, an impact lever and a trip lever, schematically represented below, left. The hammer is attached to the shaft of the rotary solenoid and, in the normal rest position, clears the impact lever. This clearance provides some free pretravel of the hammer to give it more momentum at the time of contact with the impact lever. The latter is connected to the trip lever which, in turn, triggers the shutter.

The film transport mechanism is shown schematically in the sketch, bottom, right. It consists of a ratchet type single-revolution clutch, a Geneva intermittent star wheel and a cam. The single-revolution clutch is released by the shutter trip solenoid. During the first three-quarters turn of the clutch, no film transport occurs since the Geneva is arranged to be in its idle period. During this interval, the shutter is opened, the exposure made and the shutter closed. The remaining quarter turn of the clutch then transports the film and preloads the shutter for the next exposure.







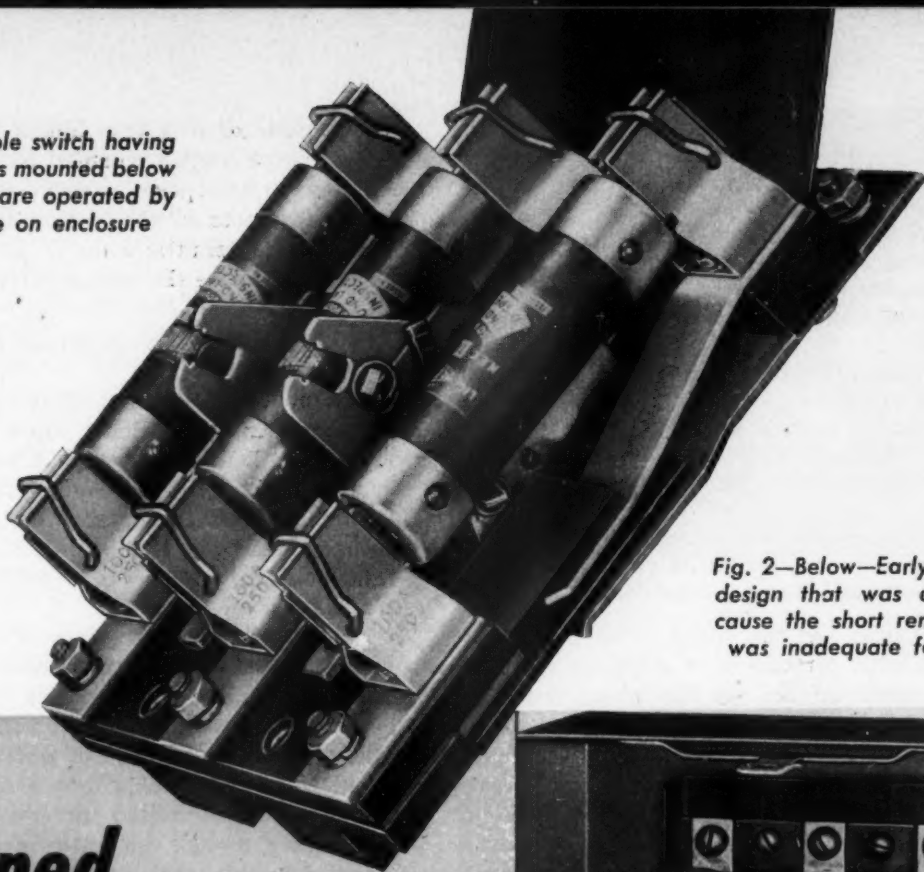


Fig. 1—Three-pole switch having contact members mounted below fuses. Toggles are operated by rotary handle on enclosure

Fig. 2—Below—Early front-operated design that was abandoned because the short removable handle was inadequate for larger sizes

Stamped Switch Mechanism

is designed for interchangeability

By Edwin Drewitz

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DESIGNED for production economy through interchangeability of parts and maximum use of stampings, the compact switching mechanism, *Fig.* 1, is a radical departure from conventional units. Sales research, undertaken during recent years with an eye toward the inevitable return of a keenly competitive buyer's market, revealed a number of interesting possibilities in heavy-duty industrial switches.

Critical comparison of enclosed safety switches shows that many designs are side-operated, deep domed-cover, knife-blade type switches with a spring-loaded quick make-and-break mechanism on the inside wall of the unit enclosure. Further these designs are space consumers, their bulk and side mounted handles preventing close group ganging.

The preliminary market search indicated that the capital investment associated with new product development was justified. The results obtained are summarized briefly in the following four primary design objectives:

1. *Smaller, more compact switch:* Such a design, compatible with NEMA and Underwriters' Laboratories Inc. requirements, would be a strong sales feature. Resultant production economies that come about through size and weight

reduction would be advantageous in a nighly competitive market

2. *Interchangeability:* To develop a basic switching mechanism that could be installed, without change, in either surface or flush type enclosures as well as in panel and switchboard units would simplify production and reduce the number of component parts for various sizes and styles
3. *Front operation:* This follows in logical sequence for two sound reasons. First it would facilitate closer ganging when a series of switches are grouped together. Second, a front operated switch could also be recessed flush in an installation
4. *Attractive appearance:* Eliminating the necessity for drawn domed covers would produce a flatter silhouette and a more economical enclosure.

DESIGN PROBLEMS: At the outset, these objectives were combined with certain other required features to arrive at a basic scheme for the arrangement of components. The fixed requirements included the necessary electrical clearances, spacings between current and noncurrent carrying parts and contact break distances as defined by Underwriters' Laboratories, together with fuse dimensions. In order to develop a compact design it was decied to "shoot for the moon" and proceed on the assumption that no switch need be any longer than its contained fuse with line and load terminals. This consideration was then expanded by a thought on horizontal contacts that could be located in "fan-folded" relationship under each fuse. These contacts were to be fixed to the switch base, one serving as an incoming or line conductor and the other connected to a fuse linked to the load conductor. A third contact mounted on an insulating member was to interpose between and bridge the stationary contacts in the circuit closed or "on" position and then shuttle away in a horizontal plane to open and insulate the circuit in the "off" position.

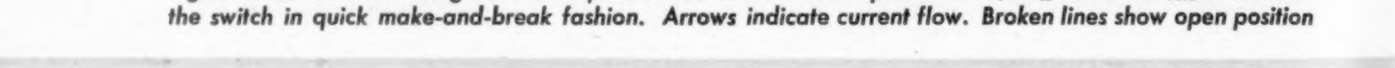
Provides for Shallow Enclosure

This novel concept appeared to be the answer to the arrangement problems posed by the first design objective. During the layout stages, however, an equally challenging problem appeared, the solution of which was vital to the realization of this first point and had to tie in with the other goals as well. This was the problem of providing front operation in a shallow enclosure.

As has already been pointed out, most switches were actuated by a spring-loaded toggle mechanism mounted to one of the side walls of the unit enclosure. This toggle powered the switch through a crank type handle, the offset portion of which, invariably, necessitated the objectionable drawn dome covers to provide clearance for radial traverse of the handle.

An early though not entirely satisfactory switch-mounted toggle arrangement, that was later abandoned, is shown in *Fig.* 2. In this design, twin toggles were situated between the poles of a three-pole switch. The toggles consisted of heavy phenolic supporting posts and cam and slide lever assemblies, energized by compression springs and pivoted against the supporting posts. The levers extended into slots provided in the interposer to couple with and direct

Fig. 3—Cross section through a 100-ampere switch in the closed position. Spring-loaded toggles actuate the switch in quick make-and-break fashion. Arrows indicate current flow. Broken lines show open position



its movement. To insure spontaneous and uniform circuit clearance of all poles, both toggles were interlocked by a connector strap to which a handle had been fastened. Herein lay the shortcomings of this design, for the handle must be removable to provide access to the center pole fuse, making it easily misplaced or lost. Secondly, the handle had to be relatively short in order to hold down the length of a necessary opening in the cover. This made operation of the larger size switches difficult without the help of an auxiliary extension handle.

The redesigned and finally adopted toggle and handle design is shown in the cross section, *Fig.* 3. This drawing also illustrates other design features of this switch. The sequence of operations beginning with the initial application of force to the new rotary automobile type handle is as follows:

Rotary motion applied to the cast aluminum handle is translated into reciprocating motion by a cam fastened to the handle and a sliding interlock member retained by twin U-shape guide cleats spotwelded to the inside of the cover. This reciprocating member has two slots through which the fixed cleats serve both as lateral guides and bumper stops. At final assembly, both legs of each cleat are bent at right angles to the guide slots to secure the slider and cam combination to the cover. Twin right angle claws spotwelded to the slider engage cutouts in the switch actuating toggles. Since all type A switches, of which class this design is a member, can only be opened and examined in the "off" position, an extension spring on one end of the slider assures the correct positioning of the interlock claws with relation to the switch toggles.

FABRICATION: About 95 per cent of the metal parts employed in this switch are designed for stamping. All cover-attached interlock parts, *Fig.* 4, with the exception of the screw-machine fabricated handle stud and cam engagement pin, are stampings. The interlock guides are a particularly good example of production-wise stamping design. This part combines in one stamping the U-cleats, a central hub for the actuating cam and a retaining hook for the positioning spring.

Subassembly Snaps Into Position

Still situated between the poles and functioning in a manner similar to the early prototype, the present switch toggles present an interesting study in economical stamping design. The toggle components, *Fig.* 5, except for the springs and an assisting pusher on the cam members (revised from a formed tab to the present screw-machine rivet to reduce friction) are stampings. Subassembly of these parts is an unusually fast operation because all three items are designed to assume their assembled relationship when snapped together by hand. All remaining metallic parts are also stampings. The line side conductor, interposer contact and upper contact along with the load side conductor are formed from flat hard-drawn copper strip, silver plated to reduce contact resistance.

Another feature of the switch is its versatility. All

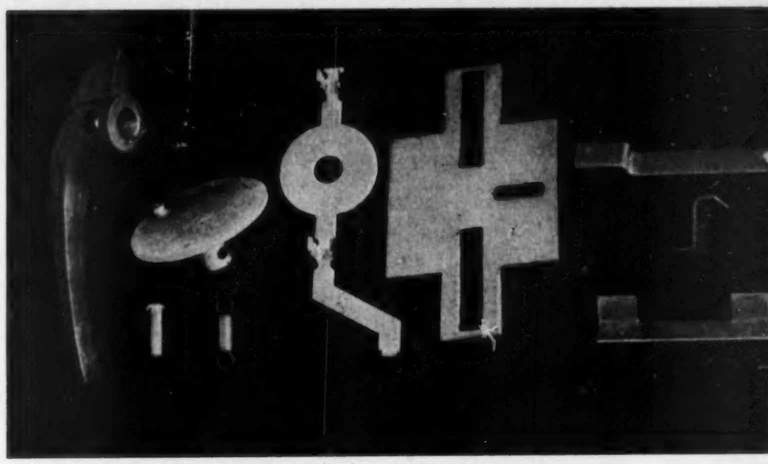


Fig. 4—Above—Actuating handle and cam with other cover-mounted interlock parts. The guide cleat stamping combines two U-shape cleats, a center washer and a hook

Fig. 5—Below—Assembled and disassembled views of the switch toggle components. The three stampings assume their assembled relationship when snapped together

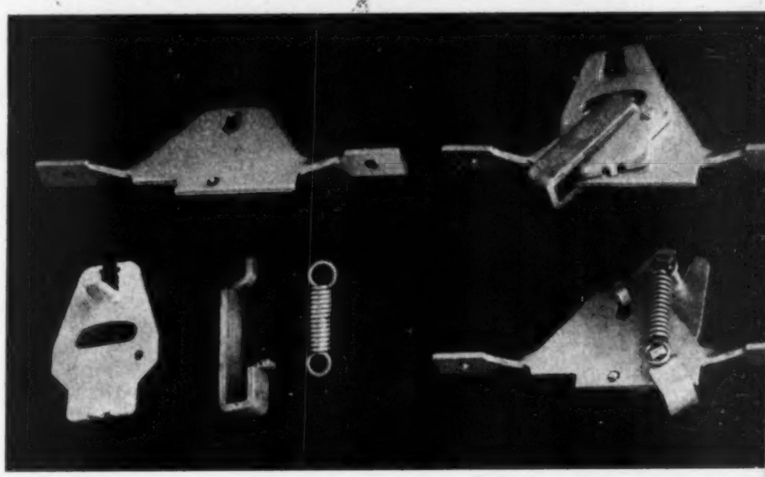


Fig. 6—Below—Comparison of cold-molded base with parts required for the preproduction fabricated base. Cost of molded base is actually less than that of a milled runner

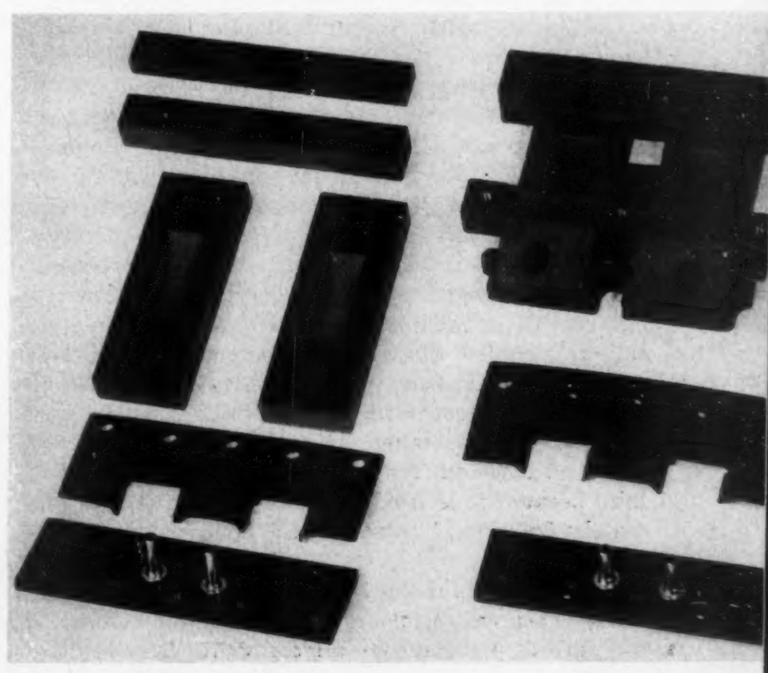


Fig. 7—Front-operated flush mounting switch is compact and does not require a domed cover

parts, with the exception of the switch bases are interchangeable between two-pole and three-pole types. The same also applies to a four-pole switch which in reality is made up of two two-pole units coupled with a common interposer.

Utilizes Built-Up Base for Testing

During the early layout and pilot model testing stages, machined and built-up phenolic strips were used satisfactorily as bases for the embryo switch. Although comparatively costly, these assembled bases were a necessary preliminary step in development and testing. Upon subsequent receipt of satisfactory test reports from the Underwriters' Laboratories Inc., the final base arrangement was returned to the drawing boards and redesigned for the molding process.

Early investigations, with respect to both strength and cost of suitable molding materials for this application, included the electrical porcelains. However, the need for opposing tapped inserts to hold the upper and lower contacts, *Fig.* 3, which must be insulated from each other to prevent a short circuit, launched a search for a substitute material. Porcelain, because it is fired to a temperature of approximately 2500 F, obviously could not retain metal inserts.

Inorganic cold-molded compositions were examined next. These materials, while they do not possess the strength of porcelain are almost identical in cost and, further, are molded without heat. After impact and flexural strength tests, a cold-molded composition known as Hemit was selected for the switch bases. Composed of inorganic substances such as asbestos fiber for filler and Portland cement for a binder, Hemit was also found to have excellent dielectric and arc resisting properties. Upon molding, this material is impregnated with either a wax or asphalt as a seal against moisture absorption. *Fig.* 6 shows an interesting comparison between the components of the present molded base and those required for the fabricated pilot models. A costly molded undercut was avoided by eyeleting the load side fuse clip bracket and a vulcanized fiber arc suppressor to the base proper.

This smaller, heavy-duty switch was not developed at the expense of other desirable features such as fuse accessibility or sufficient wiring gutters within the enclosures. Instead, size reduction and the realization of the other goals was brought about by efficient relocation of the switch components. Interchangeability has been carried to the point where the same switching mechanism may now be installed without addition or change, in every type of enclosure design. The fact that the switch actuating mechanism was relocated to the inside of the cover, no longer directly connected to the switch itself, has made this unit much more accessible for easy removal or replacement.

A slim, functional appearance was realized by completely eliminating the need for protruding domed covers, *Fig.* 7. The focal point of the design is an attractive cast aluminum actuating handle, finished in a brilliant red wrinkle in conformance with recent concepts of high-visibility color identification. Colorful lithographed nameplates, contrasting with blue-grey enclosures, complete a well-balanced color scheme.

The author gratefully acknowledges the assistance of Garfield Mfg. Co. of Garfield, N. J. and Rostone Corp. of Lafayette, Ind. in adapting the switch base design for the cold molding process.

Hose Serves As Heat Exchanger

An unusual application of flexible metal hose, as heat exchangers for generator cooling air, is found in newly designed Waukesha diesel units for mounting under railway cars. Chicago Metal Hose Corp's Rex-Weld corrugated hose is mounted on the side of the generator and cooling air circulated through it. The corrugated hose offers substantial cooling surface and is extremely compact.

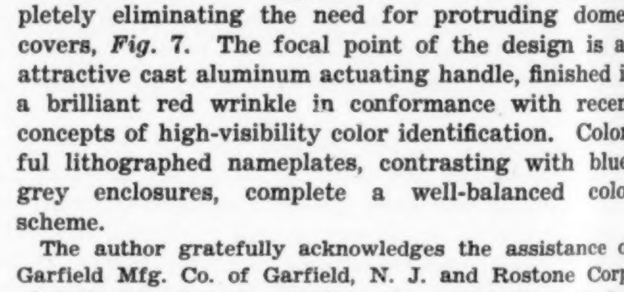
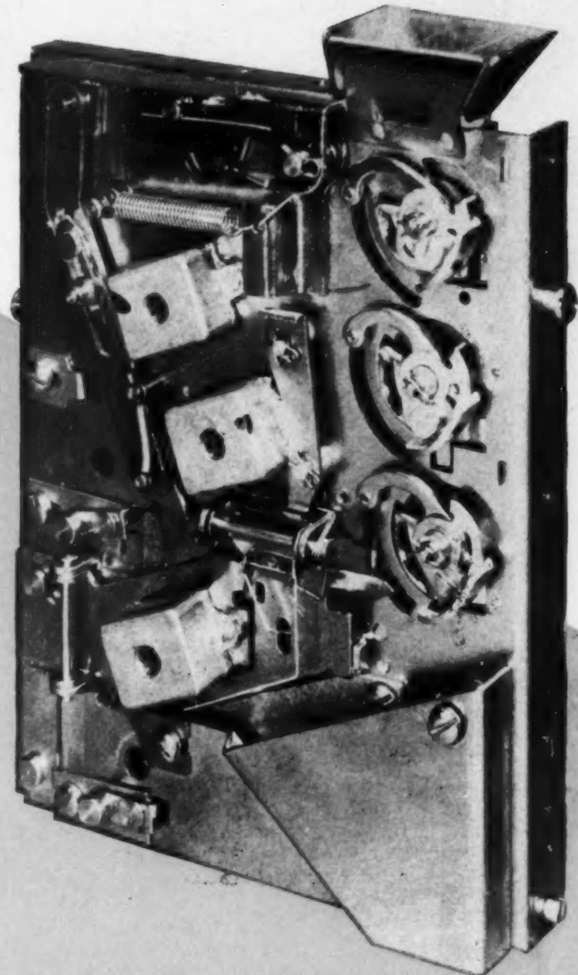


Fig. 1—Nickels, dimes and quarters are checked in this slug rejector. If size, weight, hardness and magnetic properties are correct, the control accepts the coin



Coin-Operated Controls

check for spurious coins

By W. A. Patzer

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IN THESE days of automatization, dispensing of packaged consumer goods has grown into big business. Paralleling this growth, of course, have been improvements and new developments in packaging, vending machines and coin-operated controls such as illustrated in *Fig.* 1. Vending problems, as far as design is concerned, are not simple and many headaches can develop during the creation of a dispensing unit.

Automatic vending is not new, for the first merchandising machine on record was a coin-operated water vending apparatus invented and used between 100 and 200 B. C. The first of what might be called a modern vending machine came into being about 40 years ago.

Design problems are governed mostly by the item to be dispensed, the coins to be used and the location of potential users of the machines. The fabricators of a dispensing unit should consider three factors when designing the machine. These three factors should be considered not when the machine is completed or when it is half-completed, but when the original designs are first put on paper! In the order of importance the factors are:

1. Dependability of the coin-operated control unit
2. Simplicity of operation of the complete machine
3. Cost of the complete machine.

Many fabricators of vending devices design and tool for a complete machine before selecting a coin-operated control. This is entirely wrong, because a control unit may not be available in a standard low-cost form. Of course, one could be developed and manufactured but immediately two of the above mentioned points would be defeated—simplicity of the final unit and expense of the final unit.

The success or failure of equipment depends first upon the foolproof functioning of the coin acceptance unit. Simplicity of operation of the machine as a whole cannot be stressed enough. What makes a vending machine successful is the ability of the general public to operate it with minimum effort. The machine must be so simple in construction and so understandable in operation that the prospective operator can tell at a glance exactly what he must do in order to obtain merchandise.

Cost of a machine is also a vital factor, especially to the operator or owner. Generally, the cost of a vending machine should be amortized within a period

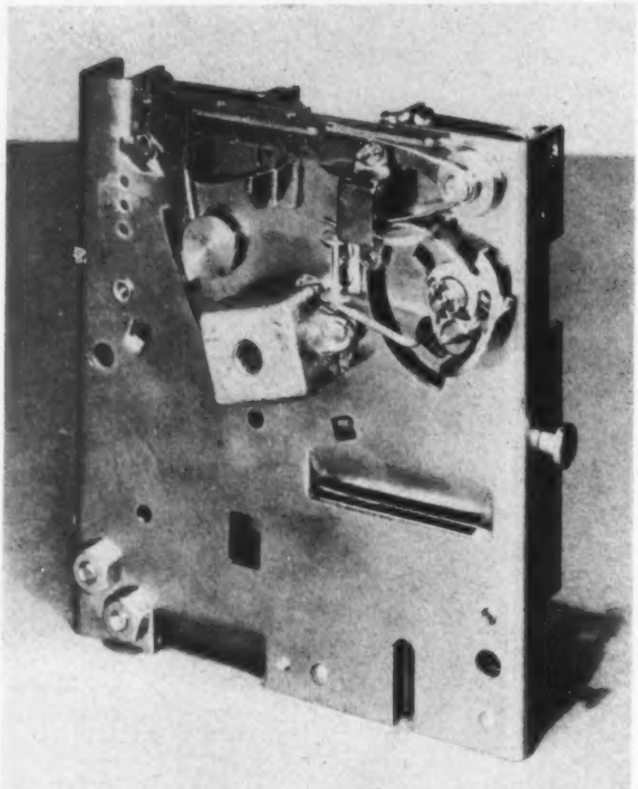
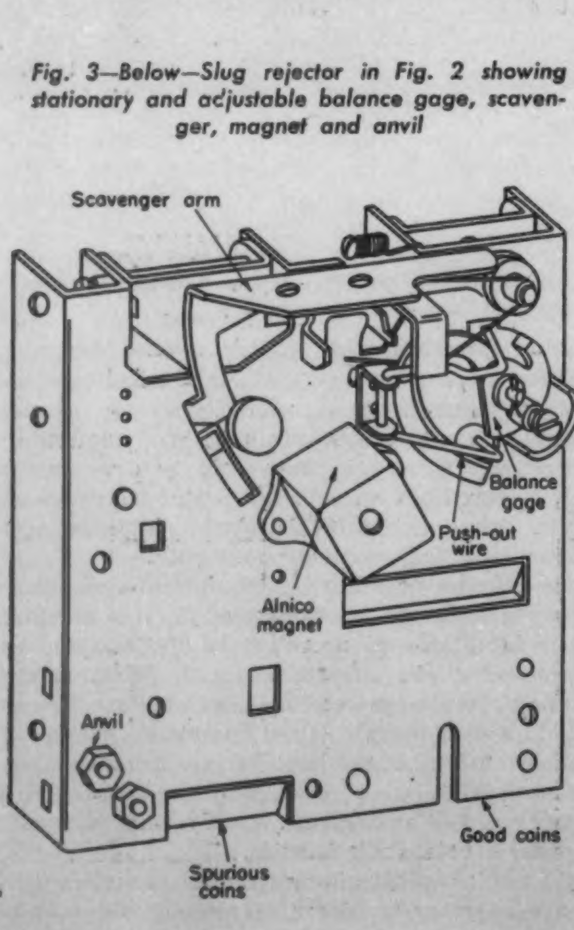


Fig. 2—Above—Basic unit for testing a single coin before operating the machine

Fig. 3—Below—Slug rejector in Fig. 2 showing stationary and adjustable balance gage, scavenger, magnet and anvil



of 12 to 18 months. Amusement devices should be amortized in 3 to 6 months.

One popular coin-operated control unit for vending machines is illustrated in *Fig.* 2 and is known as a "slug rejector." When dispensing a thing of value, the machine must be protected as much as possible from those individuals who delight in trying to cheat with some form of a slug. In a fraction of a second this slug rejector tests a coin for:

1. Diameter
2. Weight
3. Thickness
4. Metallic content.

How a slug rejector tests a coin is shown in *Fig.* 3. Attention is called to the adjustable balance gage, which swings freely from a center pivot point and is balanced by weights on one side. This balance gage could be called an off-center cradle because the weight is all on the right-hand side. The cradle has two prongs—one directly above the pivot point and one to the extreme right-hand side.

When a coin is deposited, the two prongs measure its diameter. If its weight is correct, the coin is heavy enough to over-balance the weighted cradle, allowing the coin to flow between a cover plate on the front side of the rejector and an Alnico magnet. The distance between the cover plate, or door, and the Alnico magnet checks the coin for diameter. If the coin is too thick, it is stopped immediately. As the coin passes through the electrical field, or flux, set up by the Alnico magnet, it is checked for metallic content.

After the coin passes these tests and a nickel is involved, the coin then hits an anvil, or bouncing block, and bounces across the face of the rejector from left to right and emerges as a good coin. If the coin has passed all the tests with the exception of the metallic-content test, it does not hit the anvil, or bounce block, but drops out and is returned to the customer. If the coin is oversize and is caught between the magnet and the door or is undersize and remains motionless in the cradle, the coin-return button can be pushed. This button is connected to a scavenger arm which opens the complete slug rejector mechanism and allows the spurious coin to return to the customer.

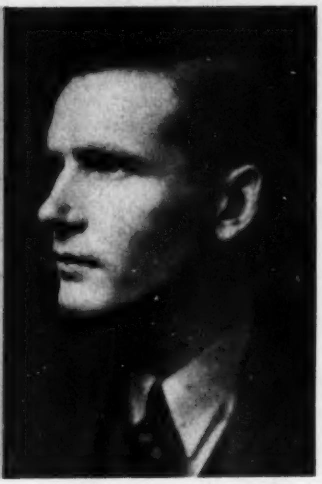
This rejector measures $4\frac{3}{8}$ by $4\frac{1}{8}$ by $1\frac{1}{4}$ inches and is the result of demands for smaller and more dependable units. Earlier rejectors had measured as much as 8 to 10 inches in width and 14 to 16 inches in length.

Magnets Check Metallic Content

Problems that arose with rejectors on the market at that time revolved around their unusual size and lack of efficiency in detecting phosphorous bronze, linotype metal and lead slugs.

Magnets are the only inexpensive means of detecting metallic content. The first magnets were cobalt and were used to detect zinc, brass and copper slugs. Cobalt, however, proved unsatisfactory because of its characteristic of losing magnetism through shock

W. A. PATZER is well known for his coin-operated robot which plays perfect defensive bridge, the machine having been played and approved by his personal friend Ely Culbertson. The author's experiments on methods and devices for detecting spurious coins were started in 1932 and, in six years, he had developed a dependable coin-operated control which is the smallest standard unit built. Having obtained degrees from three leading European universities while studying under internationally famous scientists and mathematicians, he has been project engineer for Krupp Steel Works in Germany and for Boucher Mfg. Co. in New York. With respect to inventions, he holds thirty-eight patents covering slug-rejection mechanisms for coin-operated vending machines



and vibration. This problem was overcome by the use of an Alnico magnet composed of aluminum, copper, nickel and a trace of steel. The effectiveness of this magnet over a cobalt one was increased to such an extent that the size of the magnet could be reduced to one-third the size of the former magnet. An Alnico magnet being used today measures ¾ by ⅝ by ⅝-inch. In addition to creating a strong field, the Alnico magnet withstands shock and heat to 600 F without efficiency loss.

Another problem associated with slug detection in a five-cent unit was the testing method used to reject any metal slugs with soft characteristics, such as lead, linotype metal and babbitt. The magnetic field has no effect upon these metals so other methods of detecting had to be evolved. This was done with a bouncing block, or a small piece of hardened steel. The main problem with the bouncing block is to keep soft coins from bouncing and allowing the coins with hard characteristics to bounce. This was accomplished by designing the block with a roof-shape top. The block digs into the soft slugs which fall off to the side and are rejected. A genuine nickel, due to its hard metallic composition will hit the block and bounce across the face of the rejector, indicating legal tender.

The same principles employed in a single-coin unit can be combined into another unit, *Figs.* 1 and 4, to test all three coins—nickels, dimes and quarters. Castings used, such as the door on the rejector, *Fig.* 4, must be precise in every respect. The coin runways are built into the casting and must remain accurate for the life of a unit. The metal used in these castings is Zamak No. 3, a zinc alloy. The castings

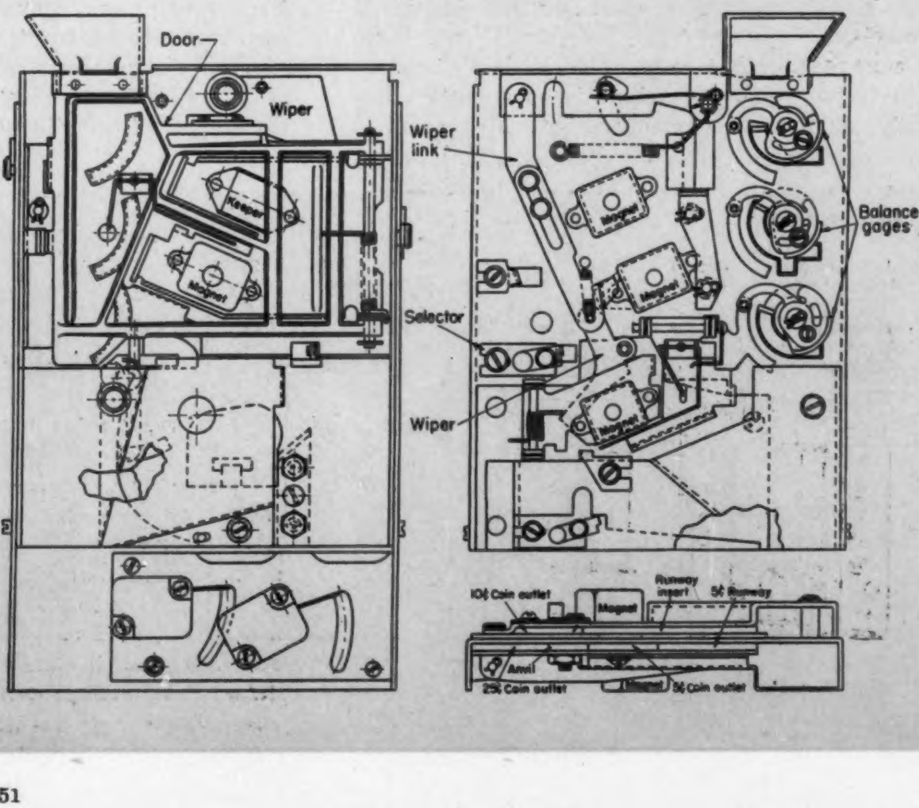


Fig. 4—Drawing for unit in Fig. 1 indicating how anvils, magnets and balances are arranged for checking coins and diverting them into individual chutes for nickels, dimes, quarters

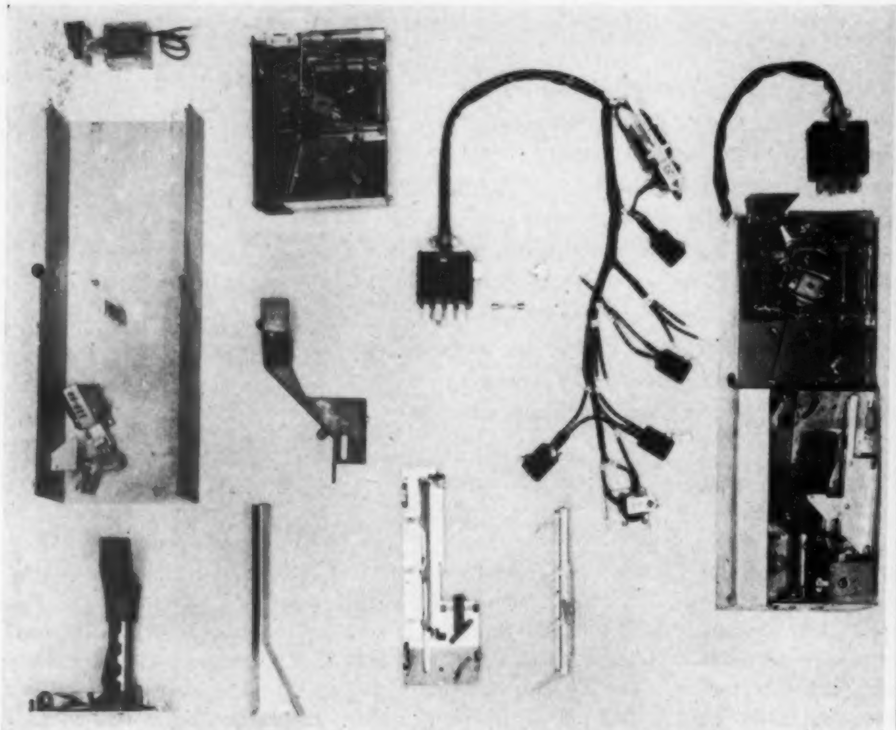


Fig. 5—Components for an electrically operated coin changer and their assembly into a unit. Change and merchandise are delivered automatically

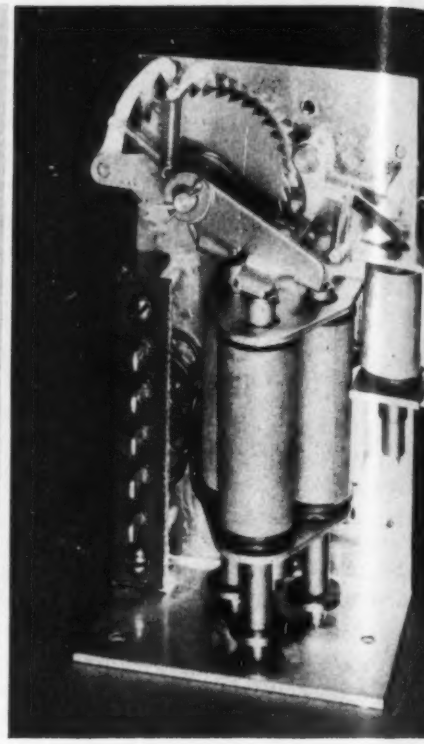


Fig. 6—Simple totalizer counts any combination of coins to total required purchase price of merchandise

are treated specially with zinc chromate which seals all pores and does not allow absorption of any kind or a chemical reaction from salt air. If plain die castings were used without some form of protection, they would absorb the dampness and salt air in coastal areas where extreme moisture conditions prevail. Corrosion and distortion would result, destroying the precision needed. All other slug rejector parts which are close to the magnetic field, are nickel-plated brass. The balance of the parts are steel and zinc chromated for protection.

The slug rejector can be mounted into an electrical package if the vending machine is to operate automatically, or it can be mounted into a mechanical unit which drops the coin into a cam arrangement, requiring the customer to turn a handle or pull a plunger to dispense merchandise.

Often, to obtain maximum sales from a vending machine, it may be desirable to employ a money changer as a coin control unit. The heart of the money changer shown in *Fig.* 5 is a slug rejector to test nickels, dimes and quarters. This unit may be adjusted for either five-cent or ten-cent merchandise, dispensing proper change in nickels. After the coin has been tested by the slug rejector, the money changer gives change automatically through the use of a solenoid which governs the actual payout of the number of coins involved.

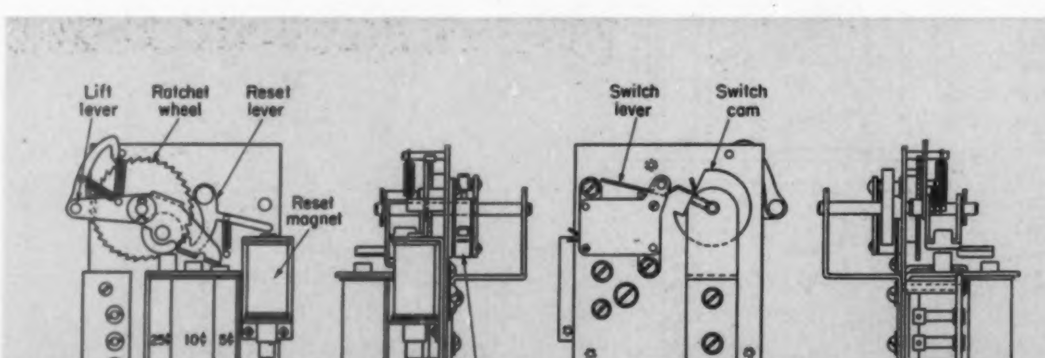


Fig. 7 — Stepping relay in totalizer is operated by three solenoids, one for each coin. Cam on ratchet wheel shaft closes precision switch to operate machine when coins reach correct total

Management Reprint

During the past few years, a considerable number of articles in MACHINE DESIGN have been devoted to up-to-the-minute appraisals of various aspects of sound engineering management. Response to these articles has been extremely encouraging and readers have requested that this material be made available as a permanent reference. To satisfy this demand, fourteen articles have been reprinted in a paperbound book, 5 by 7 inches, containing 224 pages. The book is now available at $1.00 per copy from MACHINE DESIGN Book Dept., Penton Bldg., Cleveland 13, Ohio.

Needs in the automatic vending field for a device to count money when more than one coin may be required for dispensing an item resulted in the development of the totalizer shown in *Fig.* 6. The units in the field before the development of this totalizer created problems due to their size, cost, and the job accomplished. These totalizers or step up switches were capable of stepping up only one notch or one credit at a time, when actually what was needed was to step up one notch for a nickel, two for a dime, or five for a quarter. The inexpensive totalizer in *Fig.* 6 does this job in a unit measuring approximately 2¾ by 4 11/16 by 3 inches.

Design of this totalizer, *Fig.* 7, revolves around a ratchet wheel that has a tooth every 10 degrees. To the shaft of the ratchet wheel is connected only one lift lever. Single impulses from the nickel, dime or quarter coils will step the ratchet wheel one notch, two notches or five notches, repsectively. Any combination of money can be counted in nickels, dimes or quarters, the total varying between five cents and $1.65.

On the backside of the totalizer is a switch, or series of switches, mounted with an actuating arm which can be operated from a cut-out cam attached to the shaft of the ratchet wheel. With the aid of a selector system on the vending machine, this totalizer can sell many items at different prices, the cam being set accordingly from the actuating bar of the switch. After the deposit of any combination of coins totaling the vending price, the cam will actuate the switch which in turn gives an impulse to a motor to deliver the item. Any number of switches or a bank of switches can be used, depending upon the number of items to be vended.

Relay Is Designed for Positive Stepping

The totalizer has an automatic locking device so that the coil will step up only the proper number of notches. A sudden surge of power cannot step the switch additional notches. A reset coil automatically returns the totalizer to a neutral position after an item has been vended. This is done electrically and controlled from a terminal block at the side of the totalizer.

For dispensing products where a minimum of protection is needed, less expensive coin-control equipment and simpler designs for the vending machine can be used. These controls are usually called "push slides," two types of which are illustrated in *Figs.* 8 and 9. Protection offered by a push slide usually tests only for the diameter of a coin, an undersize coin, a coin with a hole in the center, or a coin made of steel. This protection usually is about 50 per cent that offered by slug rejectors.

Automatic merchandising has become an important factor in our economy and in time will be utilized even more widely.

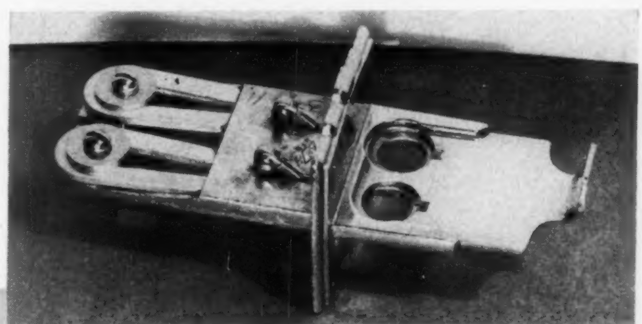


Fig. 8 — Above — Drop chute for receiving two coins. Holes in slugs or magnetic materials prevent operation

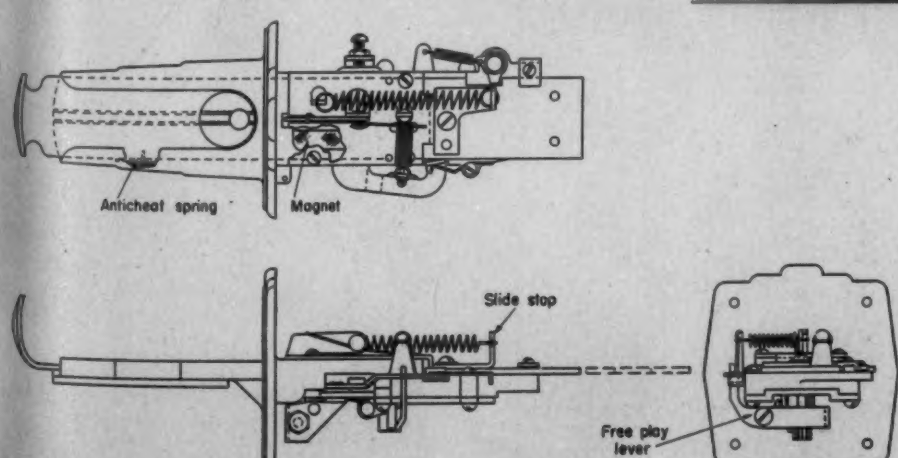


Fig. 9—Below—Simple coin chute employing a magnet rejects lightweight slugs, paper, plastic

Europea

By Paul Grodzinski

Mechanical Engineer
London, England

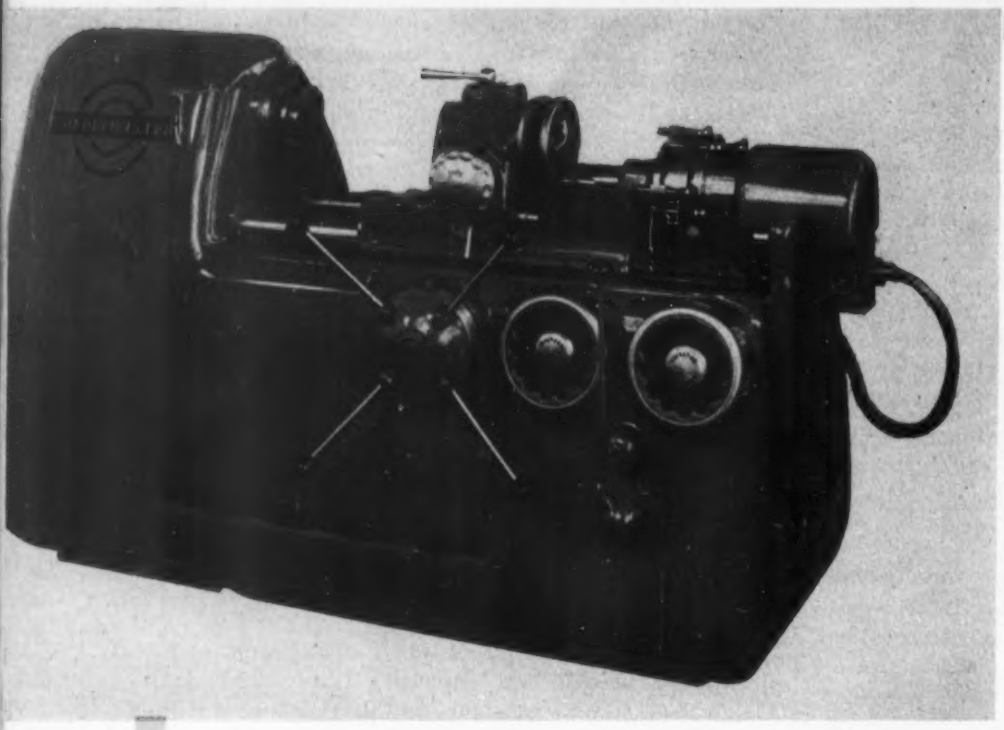
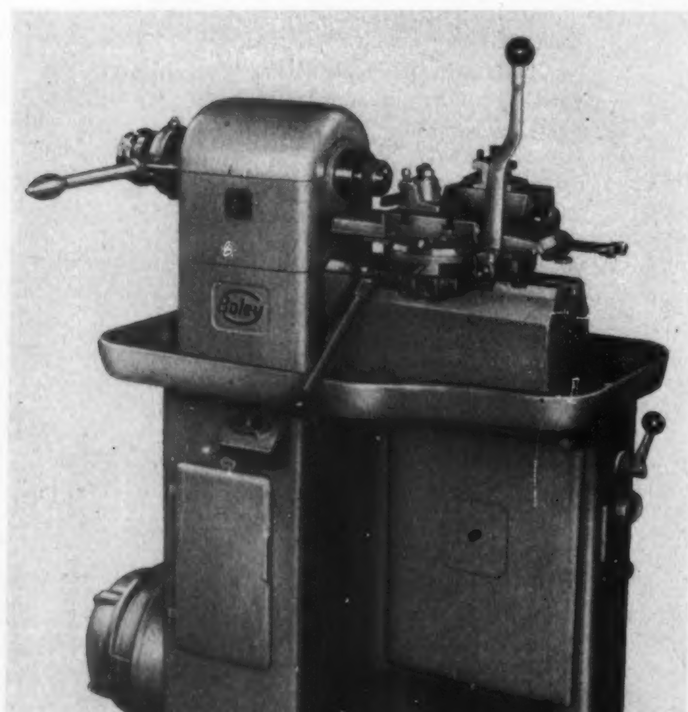


Fig. 1—Above—Gildematic horizontal axis, drum type turret lathe

Fig. 2—Below—Boley precision mechanics lathe designed for standing or seated operator position



A VISIT to several of the recent European trade fairs leaves a good general impression of the industrial capacity of the continent, evidenced by the variety of machines produced, the inventive spirit displayed and the desire to produce better machines of higher capacity.

Swiss machines shown not only at Basle but also at Hanover and Paris made an excel-

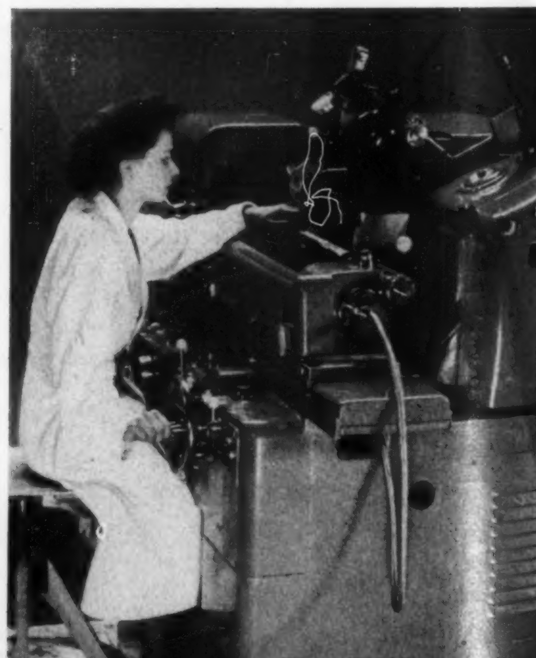


Fig. 3—Above—Offenbach MSO precision cylindrical grinder made in Germany

ea Machine Design

lent impression, in particular several new machines of exceptionally rigid design. French machines are built on clean lines, and in some instances show ingenious simplifications. German machine tools for the most part follow the lines of their prewar models.

New styling is evidenced by the German Gildemeister drum type turret lathe, *Fig.* 1, having a horizontal axis for the drum. A wide range of speeds and feeds is provided. Speed and feed changes are accomplished by an electrohydraulic synchronous control through a preselector system. A standard motor drives the machine, which is built in three sizes for bar material of 1 9/16, 2 and 2½ inches. Starting and stopping (braking) are performed hydraulically independent of the running of the motor which is thus relieved of plugging duty.

Operation of lathes with the operator seated is becoming more common, and is provided for on the German Boley precision mechanics lathe, *Fig.* 2. A special feature of this machine is the high-speed spindle (3750 rpm), with the spindle running in close-fitting diamond-bored bearings. The machine itself is most suited to turning with diamond tools. A new small turret lathe by Toenshoff for bar material up to 9/16-inch, also to be operated from the seated position, has an automatic bar feed and clamping device to relieve the operator and reduce lost time.

The new MSO cylindrical grinder, *Fig.* 3, is a high-precision machine utilizing throughfeed and infeed methods for single and series production. The complete hydraulic system for table and grinding head is built into a self-contained unit, reducing the number and length of pipes. Automatic control of the grinding operation is obtained by electrical measurement. Accuracies in diameter of 0.0001 to 0.00015-inch are maintained. Drives for the grinding wheel, workpiece, hydraulic pump and coolant pump are all through separate motors. Overriding hand operation is provided for all automatic movements.

Adjustment for different clearance angles is made possible on the French Freycenet tool grinder, *Fig.* 4, by an inclined column. By rotating this 20-degree inclined column, clearance angles from 0 to 20 degrees can be obtained. Workholder and grinding head are two separate units mounted on a common base. Necessary speeds for the use of diamond grinding wheels of 4 and 5-inch diameter are provided by a special high-speed motor.

Sintered carbide tool grinders were seen in practically all European fairs and there seems now a strong tendency to provide radiusing devices. These must necessarily have a fixed axis of rotation parallel to the face of the cup wheel, thus demanding the replacement of the swinging toolslides seen on conventional type machines. There is also the necessity of having the tool rough and finish ground with the same adjustment, necessitating bringing the tool quickly from one wheel to the other. This is in many cases achieved by swiveling the motor socket as in *Fig.* 4.

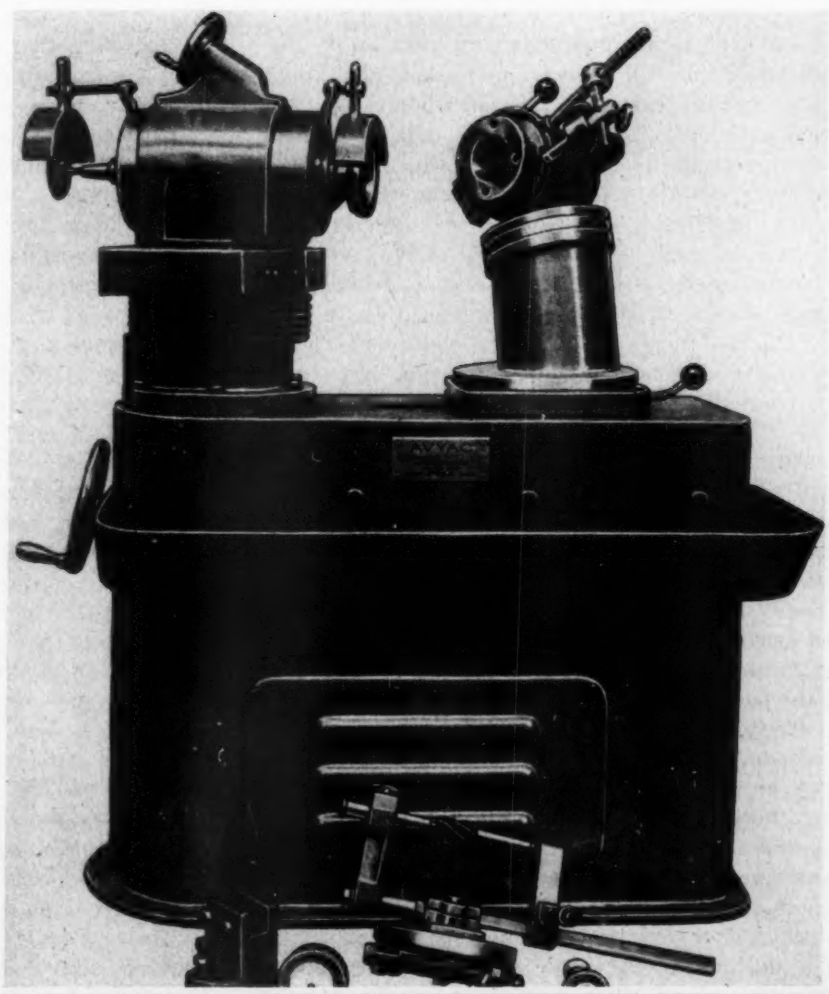
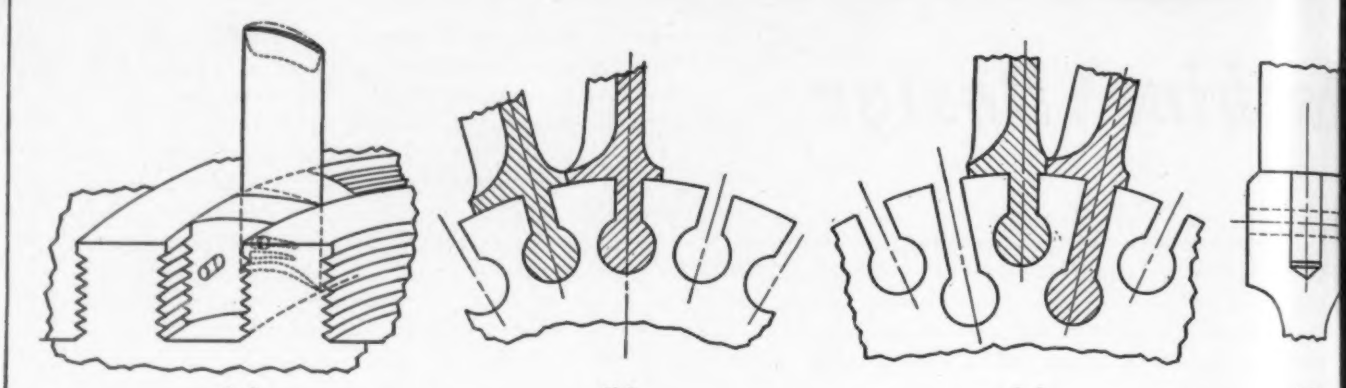


Fig. 4 — Right — Freycenet inclined column, adjustable clearance angle cutter grinder



Turbine Blade Fastenings

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By Harold Woodhouse
Morrisville, Pa.

OF ALL the elements comprising a steam or gas turbine, the rotor blade or bucket fastenings are among the most critical with respect to continued safe operation. The rotor disk is of secondary importance as a source of failure; when it does fracture, failure often originates in the area of the bucket fastening.

Advances in turbine development have progressively accentuated the critical role of the blade attachment. Rotor speeds have increased—and centrifugal loading increases with the square of speed. Temperatures in steam turbine operation have progressed from 225-325 F in early days to about 1050 F today. Similarly, with gas turbines, inlet gas temperature of about 1000 F was used in the first practical units. Today, temperatures beyond 1600 F are used. Recent intensive development of high-temperature alloys for gas-turbine applications testifies to the inadequacy of blade materials successfully used during the lower temperature era. Increased need for efficient use of material as a weight-saving means for aicraft applications has not simplified the problem.

How fastening designs have evolved to satisfy these increasingly severe conditions is depicted by the sketches on the following pages. Captions accompanying the figures supplement the review with brief discussions of origins and applications of the various fastening arrangements.

Method of fabrication is an important consideration, linked closely with both the mechanical details of blade design and the blade material. The following brief summary gives some idea of the various production approaches for different conditions.

Machined from plain (square or rectangular) bar stock. This method has always been more popular in Europe where labor costs are lower.

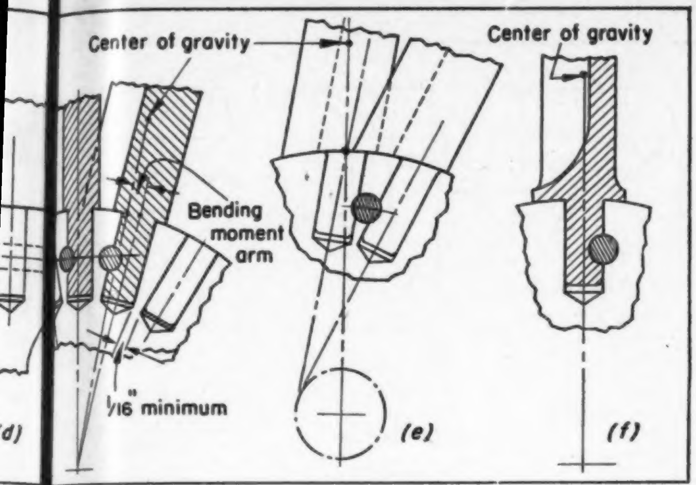
Drawn bar stock. This is sometimes used without modification to the form profile, principally for reaction turbines. For impulse turbines, the drawn bar stock offers less economy since profile and fastening details generally require additional machining work.

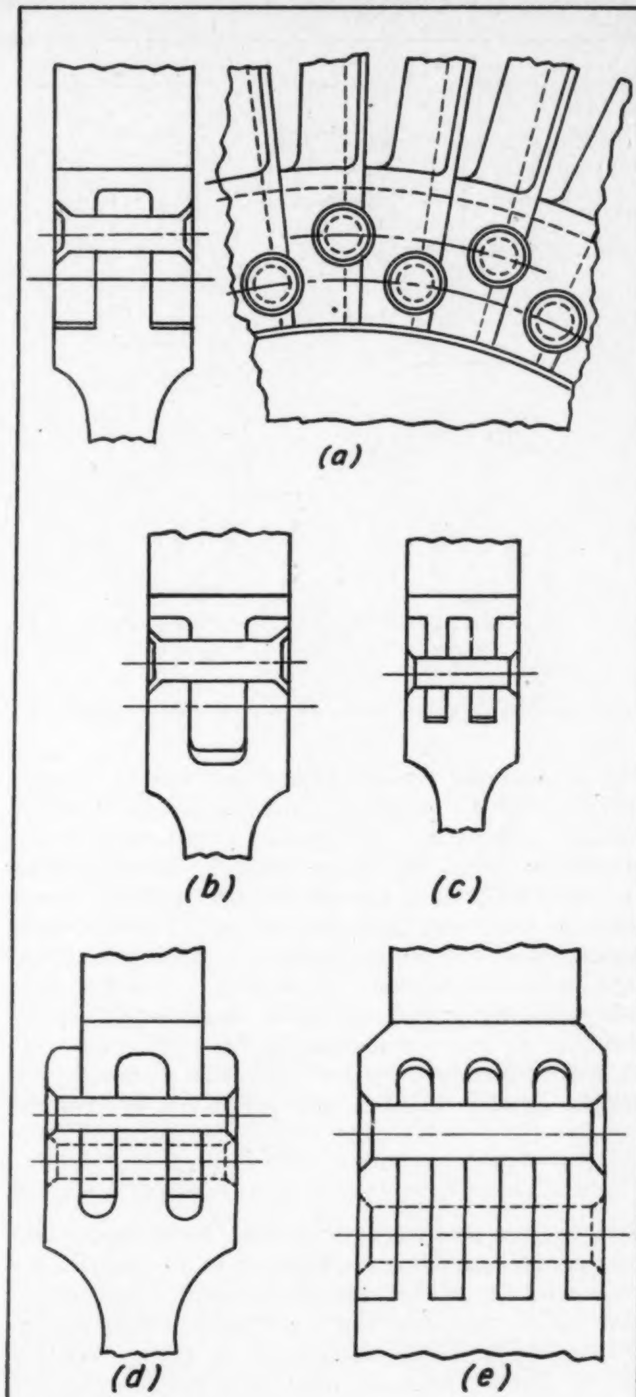
Drop forged. Hot-forged buckets are ready for use except for removal of the flashing and machining of the root and tip. This method has been used for many years with the De Laval bulb shank and reinforced base pin shank designs shown in *Figs.* 1*b*, 1*c* and 1*f*. It produces a hard skin on the bucket and thereby introduces a measure of protection against corrosion and erosion that otherwise can be obtained only with more expensive alloys.

Investment cast. The "lost-wax" method was used to produce millions of turbosupercharger buckets during World War II; the material was a Stellite alloy not readily amenable to machining. Its cost deters its use for commercial steam turbines but it is being used for gas turbines.

Tubing. Use of tubing has been restricted to a very few applications where there has been a combination of high gas temperature, a difficult-to-machine alloy such as Hastelloy B and the use of the hollow bucket as a passage for cooling air. Tubing is reshaped to the desired bucket profile with a root fastening design involving a minimum of machining.

Metal Powder. Blades consisting of pressed iron powder alloyed at high temperature with copper are being produced successfully. In this recent development, only the root needs machining.





early and modern designs

Fig. 1—Early steam turbine fastenings. Parsons reaction blading with one bucket and its adjoining spacing strips is shown at (*a*). Bucket was drawn brass bar stock cut to length without reinforcement at the bucket root. Spacing strips and blades were keyed together by "end caulking" so that the soft brass spacing strips filled narrow indentations in the lower portion of each bucket strip. Wire on which four buckets and alternating spacers were first threaded was riveted to the first spacer and brazed or silver soldered to the last blade. Early De Laval bulb-shank designs, (*b*) and (*c*), have been adapted in modified form to modern gas turbines. Short shank design (*b*) is used for lightly stressed buckets and the staggered arrangement (*c*) for more severe service. At (*d*), (*e*) and (*f*) are shown simple round-pin shank arrangements suited particularly to small steam turbine buckets where there is full arc of admission. However, area of the root pin at the junction with the cross locking pin is reduced by a significant amount. With radially mounted buckets (*d*) this condition is aggravated by a centrifugally induced bending moment with respect to the center of the pin at the base of the blade. At (*e*) this effect is eliminated by off-center mounting. At (*f*), reinforcement of the bucket root allows a more sturdy pin. The root platform, however, detracts from the smooth flow of steam and is not desirable for short buckets. In these latter designs minimum bucket pitch is limited by the proximity of adjacent pins at their deepest penetration into the rotor. Approximately 1/16-inch separation is usual. Where the bucket pitch is small, one locking pin can be used, as at (*e*).

Fig. 2—Fork type shanks and rotor rims. Forked-root type (*a*) has been used for many years, particularly on European Rateau turbines employing buckets machined from plain bar stock. Rivets are generally staggered, each so placed that it engages two adjacent buckets. Thus, area under shear is increased. Single-tang shank (*b*) has been used for buckets of medium size. For small high-speed turbines where buckets are short and narrow but centrifugal loading is high, a double-fork design (*c*) is sometimes used to give more stable, vibrationproof support than reduced versions of (*a*) or (*b*). Extensions of the same principles to larger buckets are shown at (*d*) and (*e*).

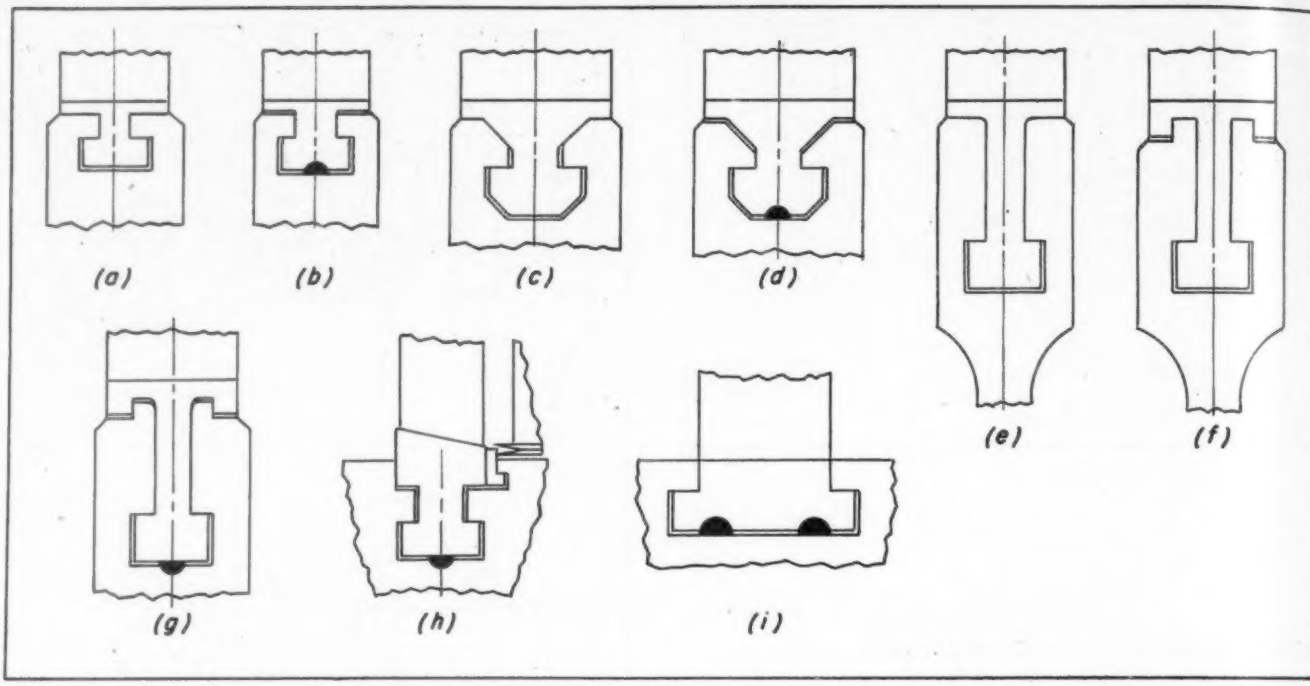
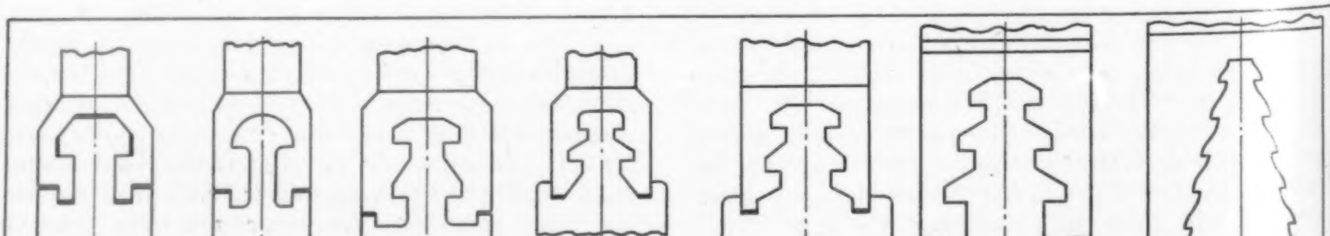


Fig. 3—Inverted tee-slot fastenings. For the simple inverted tee design at (*a*), the tee is closely fitted radially and axially so that after insertion in the slot of the rotor the bucket must be driven around the rotor until hard against the next bucket. Tolerances in the radial direction are not as critical with arrangement (*b*) which employs a half-round wedge strip under the bucket. Variants (*c*) and (*d*) provide increased throat strength. Bending stresses in designs (*a*) and (*c*) resulting from inaccurately machined contact surfaces are minimized in design (*e*) by the greater throat length which can be strained with less severe stressing. To prevent outward deflection of the rotor rim sections adjacent to the neck of the bucket under high centrifugal load, the locking arrangement at (f) is employed. Wider tolerances for this arrangement are permitted with design (*g*) where again the take-up wedge is used. Design (*h*) includes a special sealing ring retained by a miniature half-tee slot. This arrangement is designed for reaction turbines having "end tightening." Special inverted tee with two base wedges at (*i*) is favored with slight variations for gas turbine and axial-flow compressor stator vanes where loading is light.

Fig. 4—Tee, pine-tree and fir-tree fastenings. With this group, machining is simpler than for the designs shown in *Fig.* 3, because the relatively inaccessible grooves of the rotor rim are transferred to the individual buckets. All designs in this group employ a lateral locking provision since they are intended for use with medium to large-size steam turbine buckets subjected to centrifugal pull of several tons. Design (*b*), a variation of the simple tee (*a*), can be machined by form tools and offers fewer points of stress concentration. Designs (*c*), (*d*), (*e*) and (*f*) are progressively reinforced pine-tree arrangements for large steam-turbine buckets. Better stress distribution and more efficient utilization of material are provided by the fir-tree design at (*g*) which, because of complex machining, is restricted to the largest buckets. Broaching is required for all designs in this group.



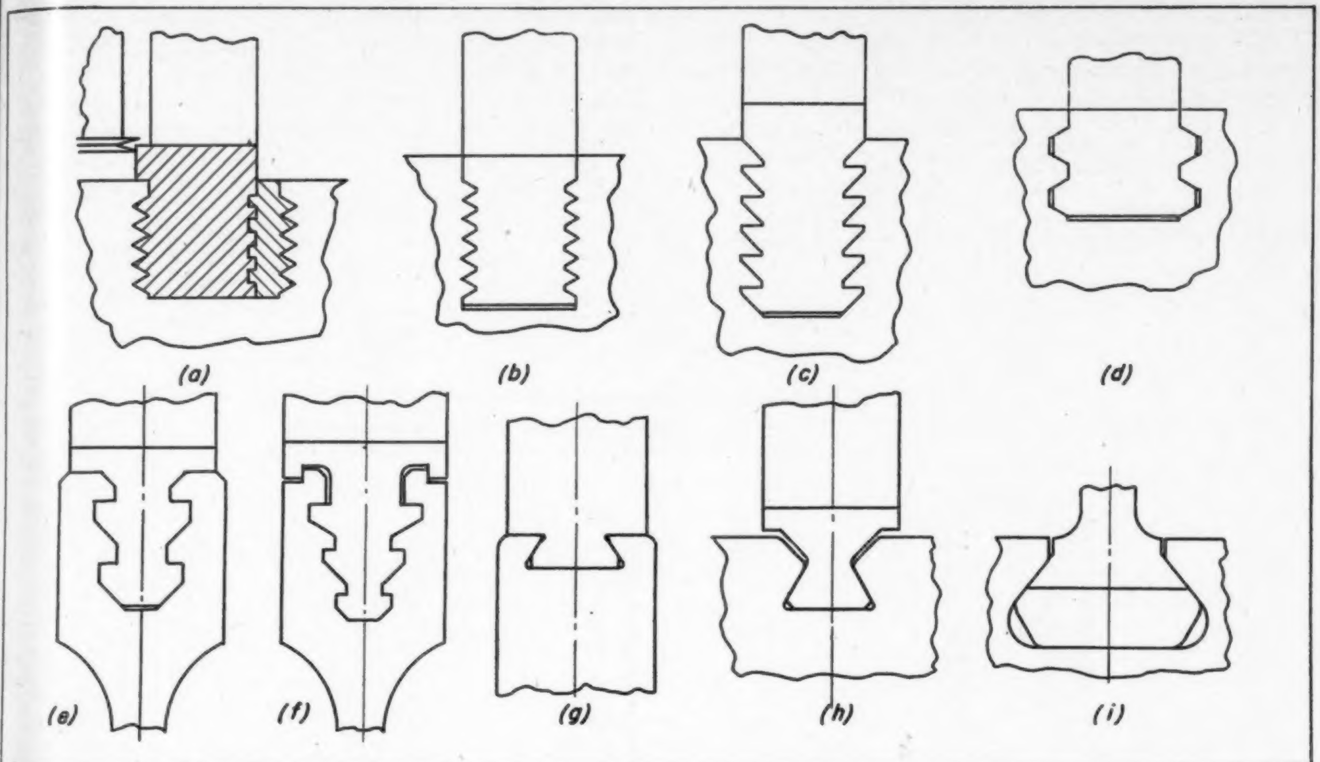
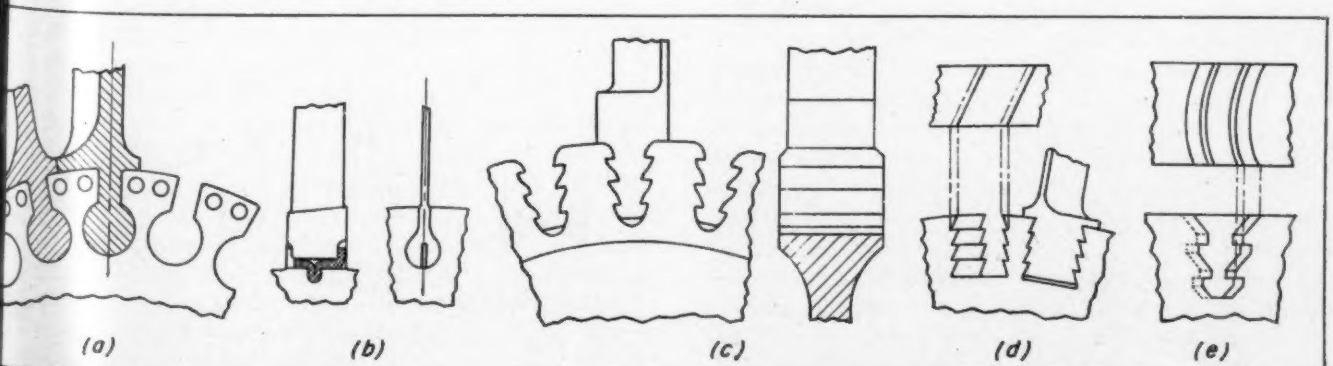


Fig. 5—Inverted pine-tree, dovetail and other rotor-grooved fastenings. Despite machining difficulties, many steam turbines have employed intricate grooving in the rotor, as shown by some of the designs in this group. With the advent of higher steam pressures, design (*a*) with end tightening was adopted by Parsons in preference to the radial tightening arrangement of *Fig.* 1*a*. The bucket, of drawn bar stock, is silver-soldered to the grooved spacer. Inserted from the end of a bucket section, the packing piece is driven into position arround the rotor rim. For added strength with long buckets running at high speed, the integral grooved root at (*b*), was introduced by Parsons. Also of European origin are the serrated groove design (*c*) and the Acme thread-section type (*d*). Inversions of the double and triple pine tree, (*e*) and (*f*), have also been used in special applications. Simple dovetail (*g*) has been used for the stationary guide vane between rows of Curtis stages and to some extent on early turbine buckets. With fillets to reduce stress concentrations, (*h*) has been tried for gas-turbine compressor blades but imperfect fitting led to over stressing. With reinforced base, (*i*) has found use in small turbine buckets.

Fig. 6—Side-entry fastenings. These arrangements offer more simple assembly and replacement of blades than most designs previously illustrated. For gas-turbine applications early bulb-shank designs of *Fig.* 1 have been modified to reduce stress concentrations and lightening holes have been added to the rotor rim as shown at (*a*). Similar version (*b*) has a locking wire to prevent end movement. Fir tree, serrated and double pine tree contours have been adapted to side-entry arrangements, (*c*), (*d*), and (*e*). Curved design (*e*) gives added stiffness but cannot be straight broached.



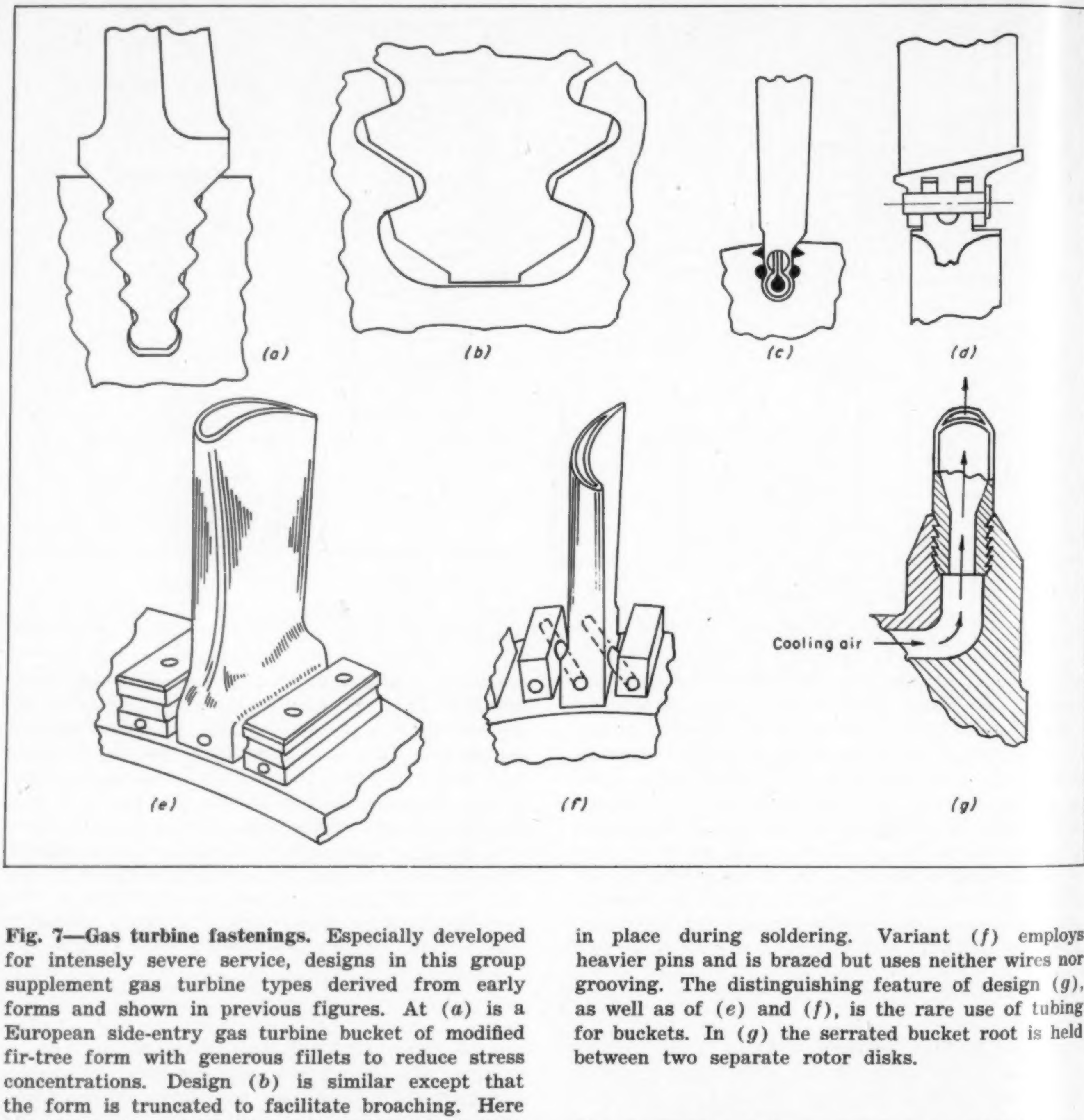
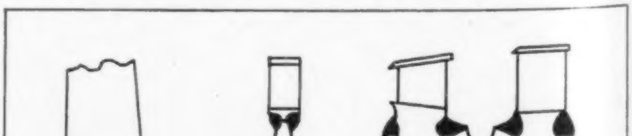


Fig. 7—Gas turbine fastenings. Especially developed for intensely severe service, designs in this group supplement gas turbine types derived from early forms and shown in previous figures. At (*a*) is a European side-entry gas turbine bucket of modified fir-tree form with generous fillets to reduce stress concentrations. Design (*b*) is similar except that the form is truncated to facilitate broaching. Here the bucket is a loose fit on the rotor but is held tightly outward against the rotor during operation by centrifugal force. Tangs bent over the rotor sides restrain lateral movement. Used by Rolls-Royce, this design has been very successful because it is sufficiently free to absorb thermal deformations without added strain. In another side-entry European type, (*c*), a steel pin is welded in the bucket root and smaller round and triangular-shaped pins are driven in both sides of the root to secure the bucket. Cooling air is directed against the bucket by a deflector incorporated in the hollow root. A variation of *Fig.* 2*c*, (*d*) is referred to as the "hinge" type. At (*e*) is shown a German design in which individual bosses are machined on the rotor rim and grooved to receive silver-manganese wire which is soldered to the bosses and the buckets. Pins hold the buckets in place during soldering. Variant (*f*) employs heavier pins and is brazed but uses neither wires nor grooving. The distinguishing feature of design (*g*), as well as of (*e*) and (*f*), is the rare use of tubing for buckets. In (*g*) the serrated bucket root is held between two separate rotor disks.

Fig. 8—Welded designs. Favored for high-temperature applications, welded construction is generally used with investment-cast high-temperature resist-



ing alloys which are difficult to machine. Two forms are shown at (*a*) and (*b*). Design (*c*) is an example of combined welding and riveting. Machined from bar stock, the buckets are riveted to the rotor disk and the shroud and rotor rim are then welded together. Since the buckets become integral with the rotor, rigidity and vibration resistance are increased and transient temperature differentials between buckets and rotor are reduced.

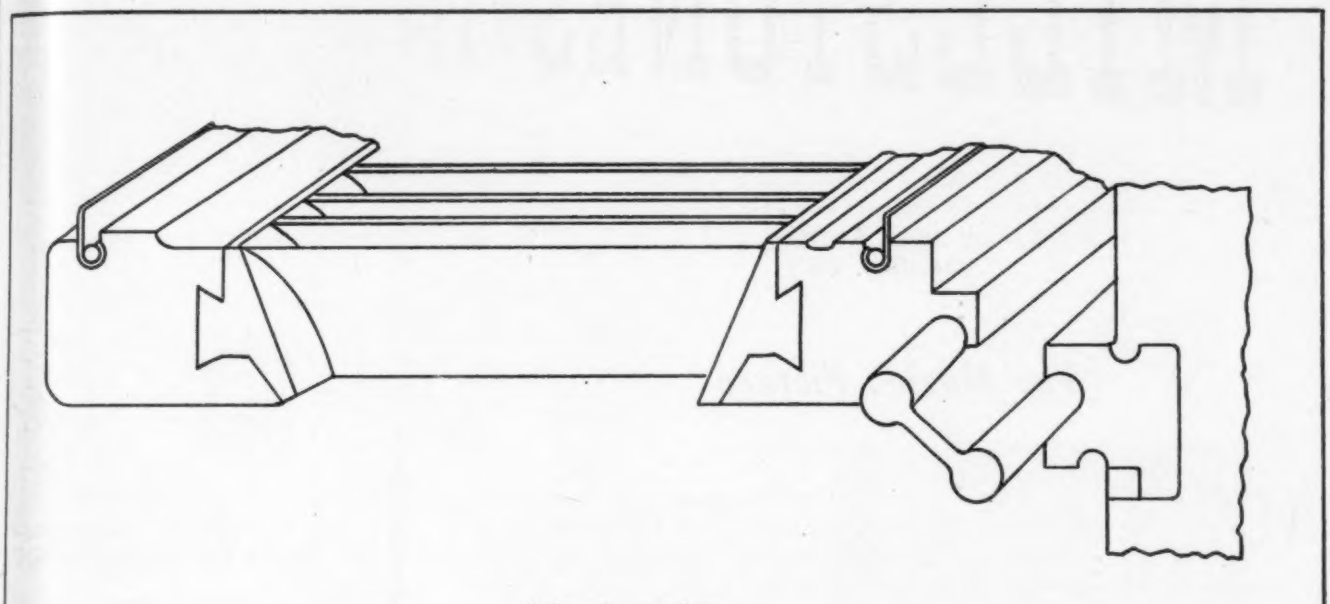
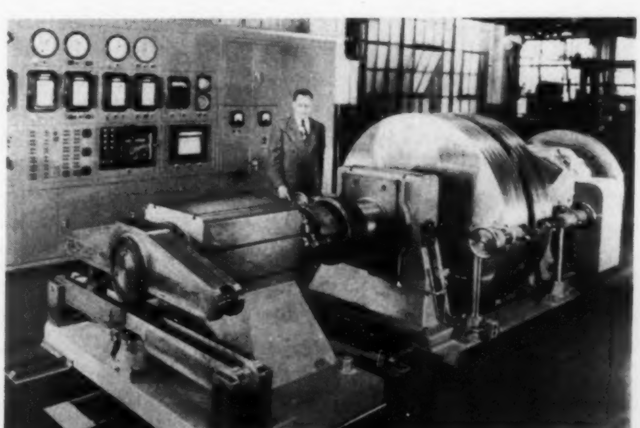


Fig. 9—Ljungstrom radial-flow turbine fastening. This Swedish design differs from other turbines in that the bucket is held *parallel* to the axis of rotation. The bucket profile is of conventional shape with simple dovetails at both ends fitting into solid concentric rings. The unique feature is the manner in which one of these concentric rings is attached to the driven rotor. A concentric ring of dumb-bell cross-section is held in ring slots in the bucket base ring and in a ring carried in the rotor disk. Edges of the slots are rolled over to secure the assembly. The dumb-bell connection permits the bucket ring assembly to seek proper adjustment under transient conditions of temperature and stress, while maintaining concentricity.

Dynamometer Tests Friction Materials

STOPPING and starting qualities of brake linings, blocks and clutch facings can be measured to an extent unattainable on any similar type of equipment by a new inertia type, heavy-duty dynamometer installed at Raybestos-Manhattan Inc.'s Passaic, N. J. plant. The machine will test materials used in stopping all types of automotive vehicles, railroad trains, airplanes and off-the-highway equipment.

When fully loaded the dynamometer can simulate the braking of a rear axle on a truck grossing 60 tons on three axles. Road speeds in excess of 200 mph can be attained, as well as speeds in the creeping range. All types of brakes—air, hydraulic pressure, vacuum, electric or mechanical—can be tested up to wheel loads of 40,000 pounds.



MILESTONES IN DESIGN

By John Kremer
Cleveland, Ohio

The Motion Picture

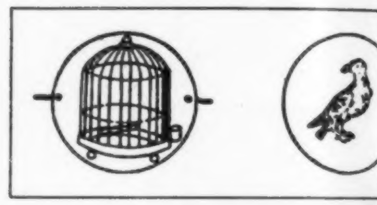
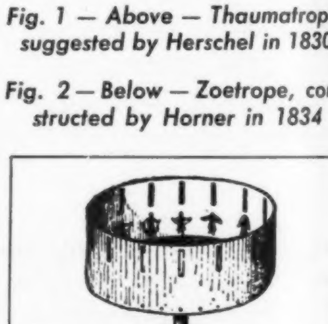


Fig. 1 — Above — Thaumatrope, suggested by Herschel in 1830

Fig. 2 — Below — Zoetrope, constructed by Horner in 1834



MOVIES taken at up to 10 million views a second have enabled designers to see how to speed up machines guns, typewriters and production machines. This "microscope for time" is the result of thinking and contriving going back amazingly far.

Zeno's speculations on the nature of motion and Ptolemy's rotating disk with spots preceded Leonardo daVinci's recognition of the eye as a camera and Newton's demonstration of persistence of vision by fifteen hundred years. Over a century ago Roget (of Thesaurus dictionary fame) wrote a paper on the apparent distortions in moving wagon-wheel spokes seen through the slats of a venetian blind. This led to a study, by Michael Faraday, of the illusions of forward and reverse motion to be seen when one toothed wheel revolves in front of another.

Sir John Herschel, astronomer and photo chemist, in 1830 predicted modern movies. He suggested a "thaumatrope" which showed a man actively moving his arm to hoist and then to lower a tankard of beer; another version showed a bird entering and leaving a cage, *Fig.* 1. This device was said by Plateau to "consist of two different objects on the opposite sides of a disk of cardboard drawn in such a manner that when the disk is rapidly spun about a diameter the combination of impressions left by the two designs creates a third. Thus with a picture of a bird on one side and a cage on the other, the bird is seen in the cage," and apparently to enter and leave it. An improvement on this device was the Plateau "plenakistoscope," an apparatus consisting essentially of a "cardboard disk pierced across its circumference by a certain number of little slots and carrying painted figures on one of its faces. So that when one turns the disk about its center in front of a mirror, looking through the slots, the figures seen by reflection in the glass, instead of confusing each other as they would on a revolving disk seem on the contrary to stop going around the circle, but to come alive and to execute the motions that are proper for them." The blank spaces between slots acted like shutters. In 1834 the mathematician Horner, celebrated for his method of solving equations of higher orders, constructed the "zoetrope," *Fig.* 2, a remarkable adaptation of the phenakistoscope which animated longer, more conveniently disposed strips of images.

Marey's celebrated motion-study pictures of racing horses, flying birds and running men taken with the photographic gun, *Fig.* 3, on different portions of a single photographic plate at rates up to 120 a second were animated in a zoetrope. The gun device, described in technical literature of 1882, was modeled after Jansen's revolver-camera used for astronomical purposes. Marey took pictures of birds in flight through the telescoping focusing barrel. The circular photographic plate was spring-revolved when the trigger was pressed so that successive portions of it were exposed by a revolving shutter as they came opposite the lens aperture.

It is paradoxical, but true, that the slow-motion

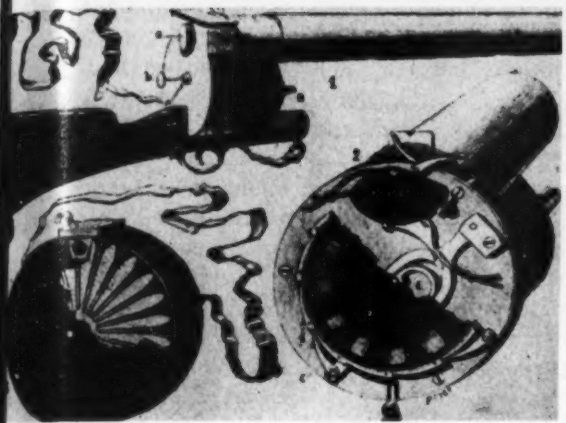


Fig. 3 — Above — Marey's photographic gun, 1882

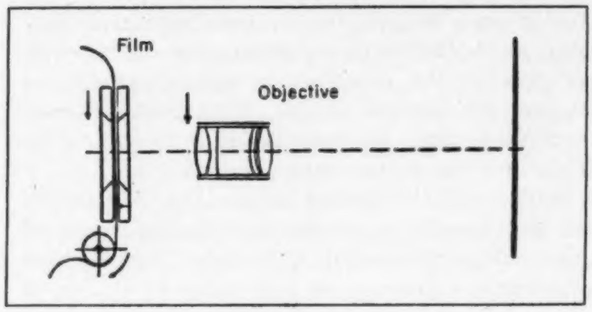
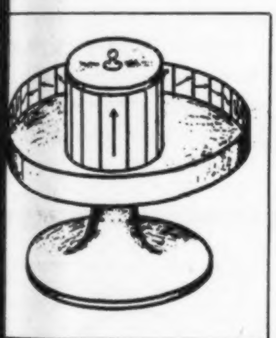


Fig. 6—Above—Jenkin's moving lens optical compensation system, 1894

Fig. 4—Below—Praxinoscope, developed by Reynaud in 1877



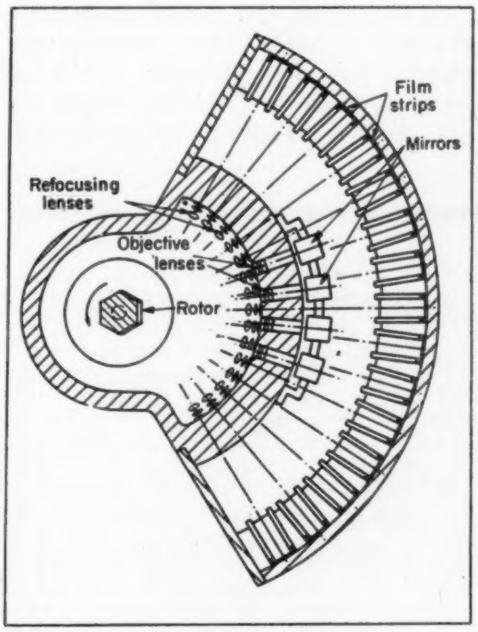
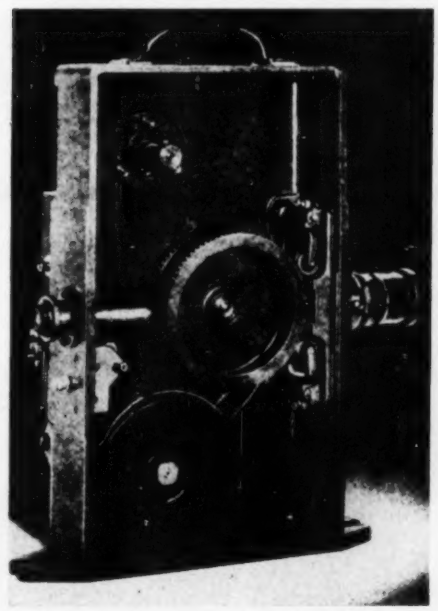


Fig. 5—Right — Modern NACA high-speed camera used for engine knock studies

Fig. 7 — Below — High-speed movie camera used with stroboscope or electrical flash illumination



or high-speed analytical movies of Jansen, Muybridge, and Marey preceded by many years the introduction of those both taken and projected at the same speed.

As Plateau realized, moving objects or pictures viewed through narrow slots appear distorted along the axis of motion. In 1869 Clerk Maxwell remedied this defect in the zoetrope by substituting, for the slots, lenses so arranged as to form the images of the moving pictures at the center of the revolving cylinder of the zoetrope. Thus the images would be apparently stationary. Also, in 1877 Reynaud did away with light-reducing slots in the zoetrope and placed mirrors half way between axis and perimeter to form stationary images at the center of the revolving cylinder, *Fig.* 4. This "praxinoscope" was combined with the stereopticon and used to protect photographs as movies before the advent of the film. Similarity between the praxinoscope and the NACA, half-million frames per second camera can be seen from *Figs.* 4 and 5, where the film in *Fig.* 5 takes the place of the eye in *Fig.* 4.

In the NACA camera, used for the study of engine knock, a stationary objective lens forms a stationary primary image on a mirror rotating at 2500 revolutions per second. The revolving reflected beam from the rotating mirror sweeps across the stationary refocusing lenses, but as the primary image is stationary and is located at the center of rotation of the reflected beam, the secondary images are also stationary and can be recorded on the stationary film strip at 500,000 frames a second if a multi-

plicity of elements and levels are provided.

Jenkins' moving lens method of 1894, *Fig.* 6, and Prince's more recent construction for apparently stopping the motion of electrical discharges proceeding at 65,000 miles a second, *Fig.* 8, demonstrate marked similarity to Maxwell's lens-compensated zoetrope. In Jenkins' scheme the objective is moved parallel to film so that the picture of the object rests steadily on the moving film. By this means a frequency up to 250 pictures per second was obtained.

The Prince pinhole camera drum, *Fig.* 8, has ten rows of 100 apertures around the circumference of the drum, which rotates at 7200 rpm. The circular ribs between the grooves on the inside of the drum strengthen it and support the film at the proper distance from the apertures, which are 0.010-inch holes spaced equally around the drum, arranged in angularly displaced bands. The slot parallel to the axis of the drum registers with only one hole at a time. It is adjustable to vary the exposure time and may be 0.030-inch in width before there is any overlap of the frames exposed by each of the "lenses."

One of the preferred ways to photograph an object moving at high speed is with the stroboscope or electrical flash-illuminated high-speed movie camera, *Fig.* 7. This instrument was anticipated by Anschutz's tachychope, *Fig.* 9, using a Geissler tube discharge as the source of momentary illumination. This was exhibited at the Chicago Worlds Fair in 1893. Recent cameras of this type have no shutters. Film moves past the focal plane at a high constant speed. The illumination is intermittent up to 30,000 flashes per second (one flash to each exposure) if low frame height is sufficient; 5000 exposures of standard 35-mm film at full height may be made in a second.

The cameras most widely used today for analysis of high-speed mechanism, when 3000 frames per second are enough, have a constant-speed revolving prism instead of a shutter. Optical compensation for continuous film movement is provided in the prism type high-speed camera, *Fig.* 10. As the opaque barrel shutter and glass prism rotate, the light enters the prism and is refracted an amount determined by the instantaneous angular position of the rotating element. Thus the image can be shifted continuously at the same rate in the same direction as the film and so is momentarily stationary with respect to it.

The foregoing principle was used in C. V. Boys' projectile-stopping camera, *Fig.* 11, first described in 1900. Here two matched lenses and prisms provide two simultaneously taken images displaced in opposite directions with respect to the film translation. A side-by-side comparison of these two opposed images, plus a knowledge of the film speed, the focal length of the lens and the distance to the stroke, permits the velocity to be calculated. Either the film drum or

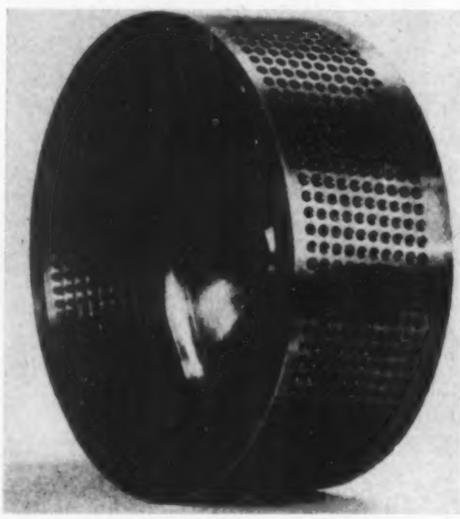


Fig. 7 — Left — Modern Prince pinhole camera drum

Fig. 9 — Left, below — Tachychope, made by Anschutz, shown at 1893 Chicago Worlds Fair

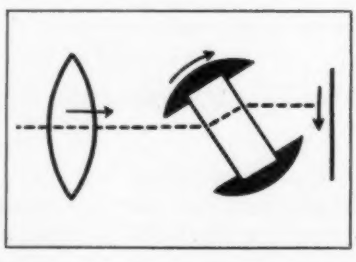


Fig. 10 — Below — Prism type high-speed camera mechanism with revolving prism

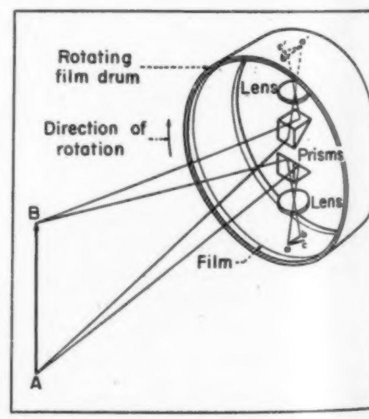


Fig. 11—Right, Above — Boys' camera for photographing projectiles, 1900

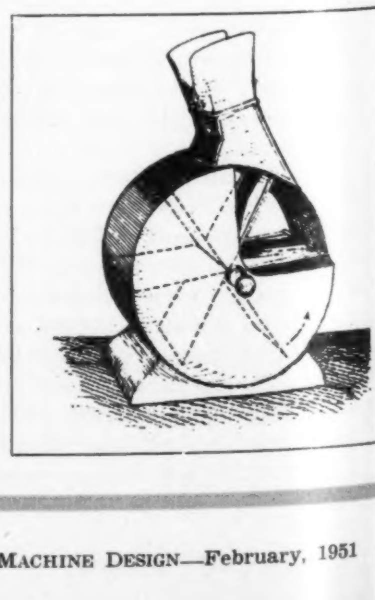


Fig. 12 — Right — Kinematoscope, 1861, developed by Coleman Sellers

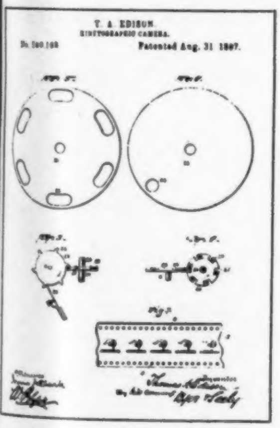
the prisms and lenses may be rotated. Where the diffracting elements are rotated, there is a similarity to the continuous film motion revolving prism design.

Evolution of the lower speed cameras and projectors is a little less clear. In 1861, Coleman Sellers made a Kinematoscope, ***Fig.*** 12, which embodied many of the principles used today. He used photographs for the first time in a movie device. He effectively brought his frames to a stop, with respect to motion in their plane, while they were being viewed. In advance of most of today's practice, he enhanced realism by a stereoscope third dimension.

In the 1880's, Edison envisioned motion picture machines having all present features except screen projection (even sound, by combination with his phonograph). He was the first to use reeled photographic film and sprocket-wheel perforations. He was first to give camera film an intermittent motion (by a brutal slot wheel). U. S. patent 589,168 of Edison's Kinetographic camera, ***Fig.*** 13, shows its general layout, with an electric motor of Edison design driving the shutter direct and, through gears and an intermittent mechanism, driving the reels that hold the film and feed it past the focal plane. ***Fig.*** 13 shows details of the shutter, the stop motion, and the film perforations. These perforations to this day remain standard throughout the world.

Edison was granted a claim on "an apparatus for taking photographs suitable for the exhibition of objects in motion, having in combination a single camera, and means for passing a sensitized tape-film across the lens of the camera at a high rate of speed and with an intermittent motion, and for exposing successive portions of the film during the periods of rest, substantially as set forth." Since he reverted to narrow zoetrope apertures for his viewer, his earliest movies could not be projected except on to the retina through a peep hole.

The Lumiere machines of more than fifty years ago, ***Fig.*** 14, closely resembled the intermittent film motion camera of today. The Lumiere film-moving mechanism included a cam, driven off a sprocket wheel, which reciprocated a slide—carrying a member that alternately engaged in and was retracted from holes in the film, thus pulling it down with an intermittent motion. A later form of the Lumiere camera, ***Fig.*** 15, (used also as a projector) had a quick-return action of the pulldown in order to leave the film stationary in the gate for a longer proportion of the time. ***Fig.*** 16 is a diagram of a motion picture camera of today. The "quick return" claw mechanism was originated by Lumiere to yank the film down when light is cut off the film. Wide film projectors no longer employ the claw but give intermittency of film motion by a Geneva similar to that which had a counterpart in the Choreutoscope of 1866.



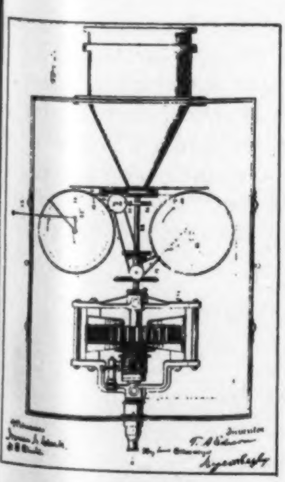


Fig. 13—Left and left below—Patent drawings of Edison's kinetographic camera, 1897

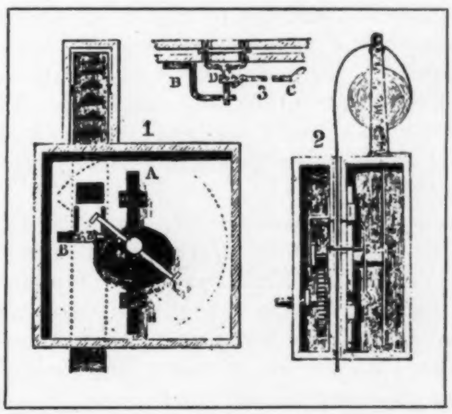


Fig. 14—Right—Lumiere intermittent film motion camera, around 1900

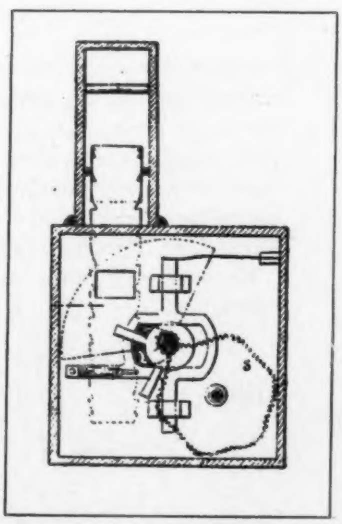


Fig. 15—Below—Later form of Lumiere camera

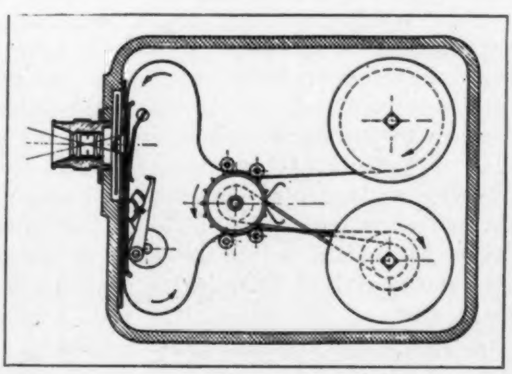
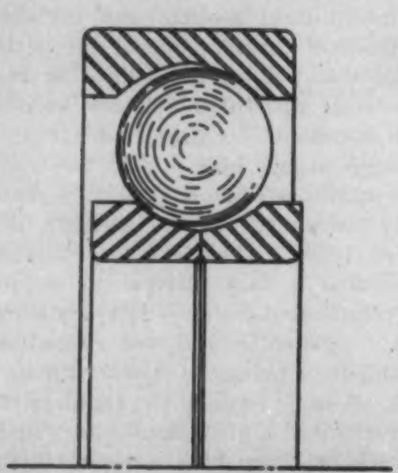


Fig. 16—Below—Motion picture camera of today with quick-return mechanism

Fig. 1—Typical double or offset-curvature ball bearing with split inner race



Ball Bearing Geometry

By Roy Krouse
Chief Technical Engineer
Fredric Flader Inc.
North Tonawanda, N. Y.

PRIOR to World War II antifriction bearing manufacturers had perfected precision machining techniques and materials suppliers were producing consistent-quality steels to give industry entirely adequate ball bearings for most machine applications. However, the advent of aircraft and industrial gas turbines and compressors has been accompanied, in general, by the requirement of greatly increased speeds over those previously employed. These new machines have raised a series of dynamic and thermal problems in bearings that had formerly given excellent service.

Certain applications of antifriction bearings require that axial motion of the rotor shaft be maintained at a value below the usual end play of a deep-groove radial bearing carrying thrust. There are two methods used by bearing designers to overcome this problem: (1) Use of two or more angular-contact ball bearings mounted to the shaft with zero (includes preloaded sets) or small end play between the races; and (2) use of double-curvature deep-groove radial type bearings. Double or offset curvatures may be ground in both or either of the races of these latter bearings, *Fig.* 1.

At high speed and load, duplex angular-contact bearings should be avoided, the author believes, although conventional calculations indicate the installation may have sufficient life. However, this article will be confined to the double-curvature type and will illustrate the effects of temperature variation across the bearing components. Heat-induced strain within the materials is not implied. The formulas here developed are useful in the checking of actual geometric conditions that arise in bearings subjected to severe service.

Basic Geometry: Illustrated in *Fig.* 2 and 3 are certain geometries of the conventional angular-contact ball bearing and the offset-curvature ball bearing. Generally, the offset curvature is ground in a split inner race. If the axial motion must be held to a lower value, the outer race also may be ground with offset curvature.

Conventional Bearing: By reference to the Nomenclature and *Fig.* 2, characteristics of the ordinary angular-contact bearing are easily defined:

Distance between curvature centers of inner and outer races,

$$r_o + r_i - d = d\left(\frac{r_o}{d} + \frac{r_i}{d} - 1\right)$$

$$= d(f_o + f_i - 1) = Bd$$

Total end play,

$$j + j' = 2Bd \sin \beta$$

Radial clearance,

$$b + b' = Bd(1 - \cos \beta)$$

Offset-Curvature Bearing: Similar fundamental relationships can be established for the double-curvature type from *Fig.* 3. Any of the following symbols additional to those given in the Nomenclature are for convenience in calculation and are defined in the illustration. Pertinent factors and their derivations, where not immediately obvious, are:

Reduction of outer race total end play by offset of curvature,

$$x_o = Bd\,[\sin \beta - \cos \beta \tan (\beta - \alpha)]$$

Also,

$$\tan \alpha = \frac{x_o \cos \beta}{Bd - x_o \sin \beta}$$

Similarly, for the inner race,

$$x_i = Bd\,[\sin \beta - \cos \beta \tan (\beta - \alpha')]$$

. . . . **calculating thermal deformations of double-curvature deep-groove radial bearings**

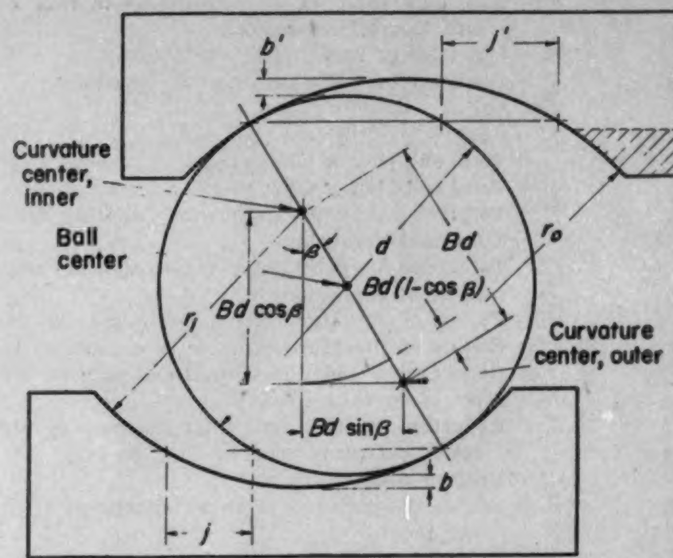
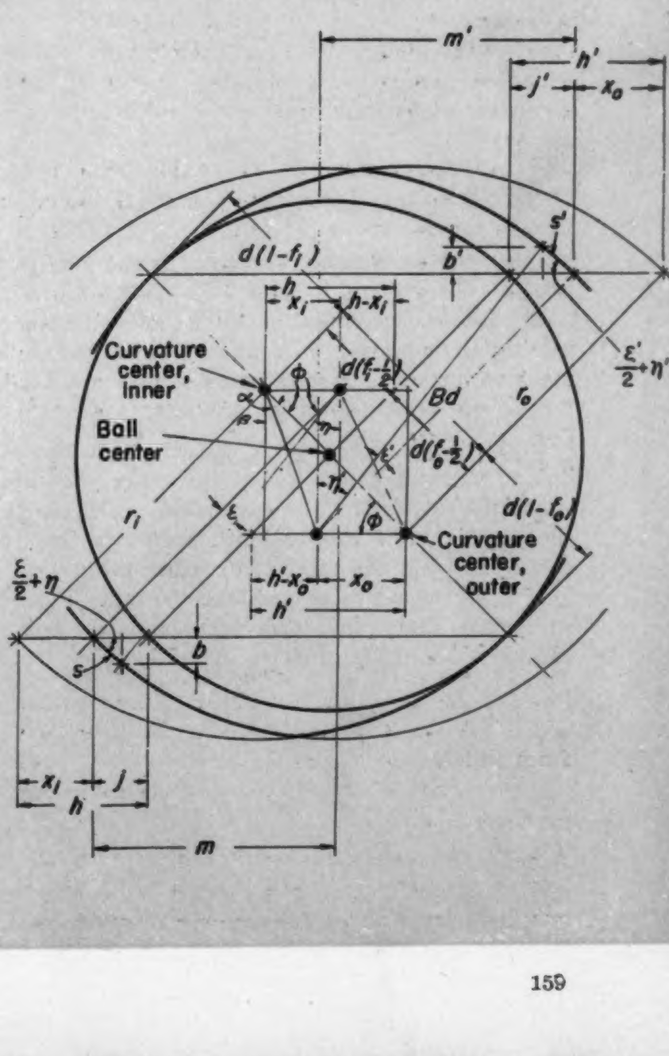


Fig. 2—Above—Geometry of the conventional angular-contact ball bearing

Fig. 3—Below—Geometry of the double curvature or offset-curvature ball bearing



$$\tan \alpha' = \frac{x_i \cos \beta}{Bd - x_i \sin \beta}$$

In order to obtain total end play, j, of inner race,

$$\sin \beta = \cos \phi = \frac{\frac{1}{2}h}{d(f_i - \frac{1}{2})}$$

$$= \frac{h}{d(2f_i - 1)}$$

or

$$h = d(2f_i - 1) \sin \beta$$

Then

$$j = h - x_i$$

$$= d(2f_i - 1) \sin \beta - x_i$$

Similarly, total end play of outer race,

$$j' = h' - x_o$$

$$= d(2f_o - 1) \sin \beta - x_o$$

Hence total bearing end play,

$$j + j' = 2B_d \sin \beta - x_i - x_o$$

Radial clearance is found also by means of several other factors:

$$m = f_i d \cos \phi = f_i d \sin \beta$$

$$\sin \eta = \frac{m - \frac{1}{2} j}{f_i d}$$

$$= \frac{f_i d \sin \beta - d(f_i - \frac{1}{2}) \sin \beta + \frac{1}{2} x_i}{f_i d}$$

$$= \frac{\sin \beta + \frac{x_i}{d}}{2f_i}$$

Nomenclature

b = Radial clearance of inner race
b' = Radial clearance of outer race
$B = f_o + f_i - 1$
B' = Any new value of B resulting from race or ball thermal expansions
d = Diameter of ball
d' = Diameter of ball after thermal expansion
$f_i = r_i/d$
$f_o = r_o/d$
j = Total end play of inner race
j' = Total end play of outer race
j'' = Total end play of inner race resulting from thermal expansion
j''' = Total end play of outer race resulting from thermal expansion
r_i = Radius of curvature of inner race groove
r_o = Radius of curvature of outer race groove
x_i = Reduction of inner race total end play by offset of curvature center
x_o = Reduction of outer race total end play by offset of curvature center
β = Bearing contact angle
Δ_i = Radial thermal and press fit expansion of inner race
Δ_o = Radial thermal expansion of outer race
Δ_B = Diametral thermal expansion of ball

$$\varepsilon = 90 - (\phi + \eta) = \beta - \eta$$

With ε converted to radians

$$s = \varepsilon f_i d = (\beta - \eta)\, f_i d$$

$$b = \sqrt{(\beta - \eta)^2\, (f_i d)^2 - (\tfrac{1}{2}\, j)^2}$$

Similarly

$$b' = \sqrt{(\beta - \eta')^2\, (f_o d)^2 - (\tfrac{1}{2}\, j')^2}$$

Finally, the total radial clearance is the sum of these two, $b + b'$.

If possible, the radial clearance and all values pertaining to it should be computed with a calculating machine since the results being sought are small differences of relatively large numbers.

INNER RACE EXPANSION: Effects upon the system due to thermal expansion of the inner race are diagrammed in *Fig.* 4. The expansion, Δ_i, is the sum of the expansion of groove-depth radius to the bearing center line and the groove curvature radius, r_i.

If Δ_i is the result of pressing the inner race on the supported shaft, the term increasing the curvature radius, r_i, should be ignored. Thus,

$$B' = f_o + f_i' - 1$$

from which

$$B' - B = f_i' - f_i$$

Also,

$$\theta = \frac{(\beta + \psi)}{2}$$

$$t = \frac{\Delta_i}{\tan \theta}$$

$$\cos \psi = \frac{Bd \cos \beta + \Delta_i}{Bd} = \cos \beta + \frac{\Delta_i}{Bd}$$

The change in contact angle is $\beta - \psi$ if the race curvature, r_i, does not expand. The true contact angle after thermal expansion is γ, as shown in *Fig.* 4, where

$$\cos \gamma = \frac{Bd \cos \beta + \Delta_i}{B'd} = \frac{B}{B'} \cos \beta + \frac{\Delta_i}{B'd}$$

The formula for α is derived in the following steps:

$$a = \frac{(B' - B)\, d}{\sin \theta} = \frac{r_i' - r_i}{\sin \theta}$$

$$w = \frac{t}{\cos \theta} = \frac{\Delta_i}{\tan \theta \cos \theta} = \frac{\Delta_i}{\sin \theta}$$

$$\alpha = \frac{w - a \cos \theta}{Bd}$$

$$= \frac{\Delta_i - (r_i' - r_i) \cos \theta}{Bd \sin \theta}$$

Also, from *Fig.* 4,

$$u = d(f_o - \tfrac{1}{2})\, \alpha$$

$$p = u \cos \theta$$

When

$$p = d(f_o - \tfrac{1}{2}) \sin \beta - \tfrac{1}{2}\, x_o$$

the ball will ride with two-point contact on the outer race. This illustrates one of the several conditions that may be found by a study of *Fig.* 4. If double curvatures are used on both inner and outer races, analysis can show whether j'' becomes zero before j''', or whether the reverse sequence is true.

BALL EXPANSION: The geometry for thermal expansion of the ball is given in *Fig.* 5. Besides the basic use of the formulas for the growth of the ball, change in geometry of the bearing (contact angle, end play, etc.) caused by the bearing load can also be determined.

When a load is applied to the bearing, the balls and races are indented. The sum of these deformations is easily determined and is equivalent to a reduction in the ball diameter of the same amount. For this condition, Δ_B becomes negative.

For a change in ball diameter

$$B' = \frac{r_i}{d'} + \frac{r_o}{d'} - 1$$

From *Fig.* 5,

$$v = (f_o - 1/2)\ d \cos \beta$$

$$\sin (90 - \beta + \theta) = \frac{v}{(f_o - \tfrac{1}{2} - \tfrac{1}{2}\, \Delta_B)\, d}$$

$$= \frac{(f_o - \tfrac{1}{2}) \cos \beta}{f_o - \tfrac{1}{2} - \tfrac{1}{2} \Delta_B}$$

Also,

$$\cos (90 - \beta + \theta) = \sin (\beta - \theta)$$

$$g' = (f_o - \tfrac{1}{2}) d \sin \beta - (f_o - \tfrac{1}{2} - \tfrac{1}{2} \Delta_B) d \sin (\beta - \theta)$$

By proportion and substitution

$$g = \frac{g' Bd \cos \beta}{v}$$

$$= \frac{Bd[(f_o - \tfrac{1}{2} \sin \beta - (f_o - \tfrac{1}{2} - \tfrac{1}{2} \Delta_B) \sin (\beta - \theta)]}{f_o - \tfrac{1}{2}}$$

where $2g$ is the change in bearing end play and $\beta - \theta$ is the resulting contact angle.

This analysis pertains to a bearing whose inner and outer race curvatures are the same or nearly so. If the curvatures are appreciably different, the function of the new contact angle is simply

$$\cos (\beta - \theta) = \frac{Bd \cos \beta}{B'd'}$$

Outer Race Expansion: Expansion of the outer race, diagrammed in *Fig.* 6, allows the bearing designer to control indirectly the bearing geometry in order to avoid drastic reduction of the initial contact angle from thermal effects. From the previous studies it is obvious that expansion of the inner race and growth of the balls decrease the original contact angle of the bearing. Expansion of the outer race increases the contact angle.

If the outer race is assembled line-to-line with the housing bore, and the housing remains at a comparatively lower temperature, complete loss of contact angle and crushing of the balls can ensue. To prevent this, the bearing outer race should be so mounted that it can expand to the bearing bore by the required amount to maintain an adequate contact angle.

For expansion of the outer race,

$$B' = \frac{r_o'}{d} + \frac{r_i}{d} - 1$$

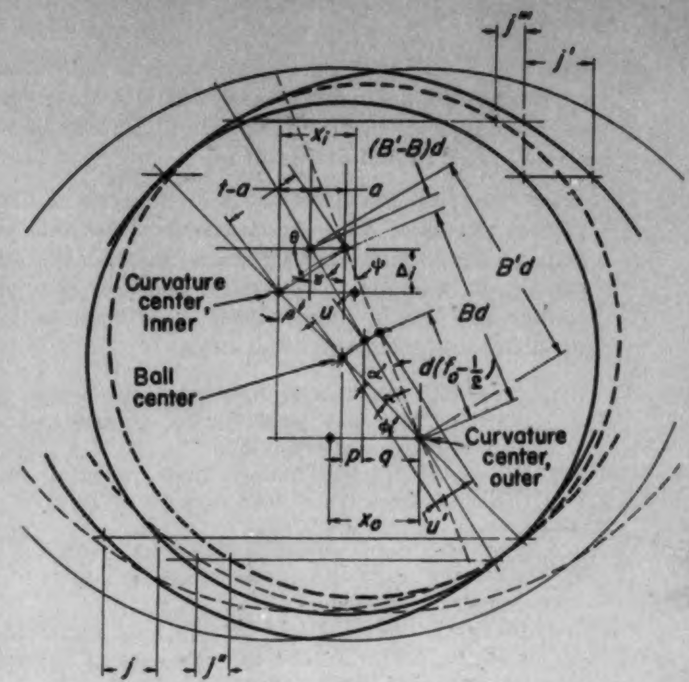
$$\lambda = \frac{\beta + \psi}{2}$$

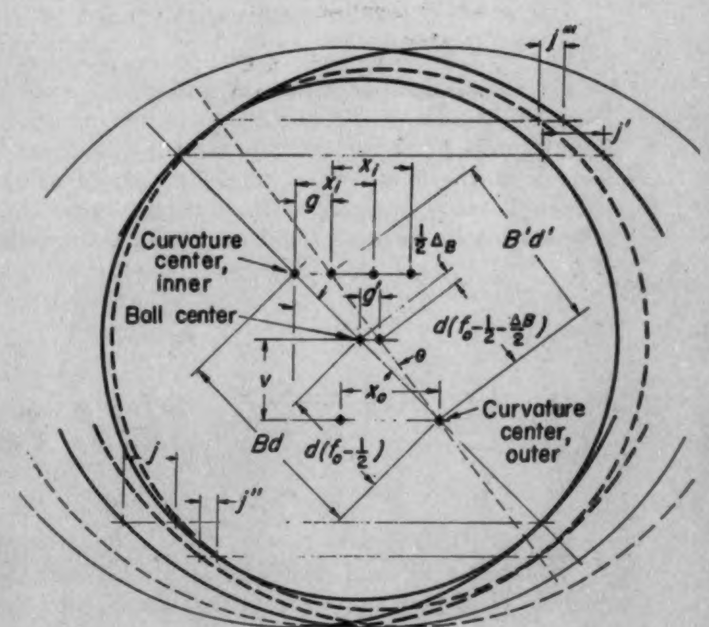
$$t = \frac{\Delta_o}{\tan \lambda}$$

And

$$\cos \psi = \frac{Bd \cos \beta - \Delta_o}{Bd} = \cos \beta - \frac{\Delta_o}{Bd}$$

$$\cos \gamma = \frac{Bd \cos \beta - \Delta_o}{B'd} = \frac{B \cos \beta}{B'} - \frac{\Delta_o}{B'd}$$





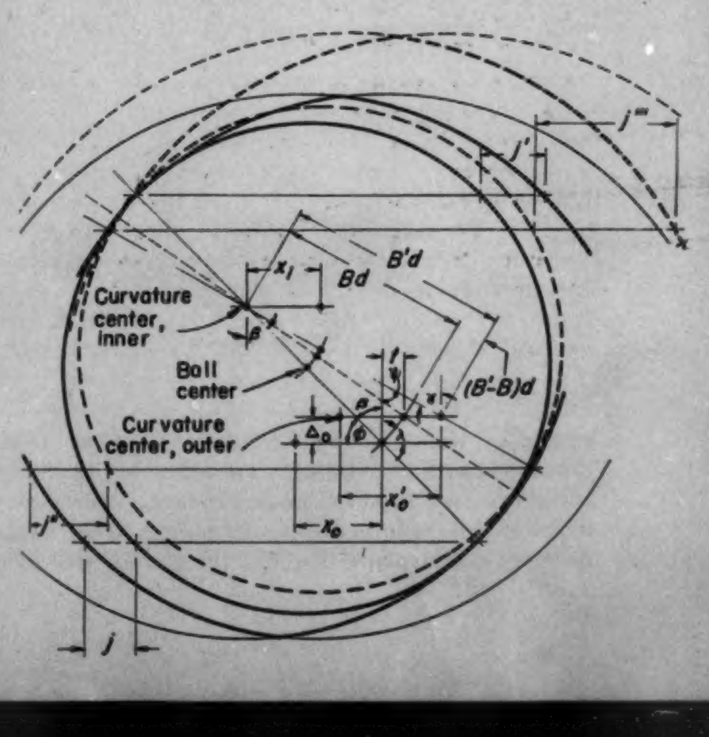


Fig. 4—Top—Geometry of the double-curvature bearing for thermal expansion of the ball

Fig. 5—Center—Geometry for expansion of the inner race

Fig. 6—Right—Geometry for expansion of the outer race

where ψ is the resulting contact angle if the radius of curvature did not change, and γ is the true contact angle caused by the race expansion and the increase of the outer radius of curvature.

Calculation Procedure: In an analysis of the expanded effects of all components upon the final bearing configuration (before load deformations are found), it is apparent that after the first component change the second component change must be based upon the new geometry. The steps are:

1. Determine the temperature variation across the bearing. This may be estimated, or better, based upon previous test experience
2. Calculate the new contact angle resulting from the shaft press. Do not account for race curvature expansion
3. Allow the outer race to expand freely. Solve for the value of B' under this condition and find the contact angle
4. Using the values found in step 3 as initial ones, solve for a new B' and the new contact angle for the expanded ball
5. Using the values of step 4, find the new value of B' and the resulting contact angles caused by the inner race expansion.

If full expansion of the outer race is not required, a controlled looseness could be permitted to give a gentle press fit of the outer race in the housing. Of course, if the final contact angle is reduced below a desirable value, the original fitup must be altered and the calculation process repeated. Load deformations may be checked after this procedure is completed.

Example: Following are the conditions for a deep-groove radial bearing: bore = 30 mm; outside diameter = 72 mm; width = 19 mm; number of balls = 8, ½-inch diameter; contact angle = 15 degrees; f_o (outer race) = 0.52; f_i (inner race) = 0.51; outer race temperature = 150 F; inner race temperature = 200 F; ball temperature = 225 F; inner race press = 0.0001-inch; average temperature of mounting housing = 80 F; ambient temperature = 70 F. The outer race was allowed to expand radially 0.00055-inch. Since the housing bore increased radially 0.0001-inch, the outer race was retained axially and assembled 0.0004-inch loose.

Outer race expansion. The contact angle increased from 14 to 23 degrees. (Press reduced the original contact angle 1 degree.)

Ball expansion. The contact angle decreased from 23 to 21 degrees.

Inner race expansion. (Final geometry) The contact angle decreased from 21 to 6 degrees.

Since, under load, deformation of inner and outer races and balls is equivalent to use of balls of smaller diameter, a trial-and-error approach was employed to find the contact angle for load conditions. For the design thrust load of 600 pounds, the contact angle increased from 6 to 15½ degrees.

The bearing life had been determined for the initial angle of 15 degrees. If final results had not closely agreed, a change in the initial contact angle and a recheck of life and angle would have been required.

Skid Tests Studied

Automobile drivers can take a tip from the latest skid tests conducted at Air Materiel Command Headquarters, Wright-Patterson Air Force Base, Dayton, Ohio. They show that jamming on the brakes at very high speeds melts the rubber and results in hardly any stopping effect. The tests are

staged by the Air Force to simulate aircraft landing conditions and get the data needed to design lighter, stronger, and smaller landing gears. Through the tests, engineers intend to learn exactly what happens between the airplane tire and the ground at the precise instant of landing on different types of runways.

Used in the experiments is a salvaged B-26 airplane whose wings have been clipped to avoid "lift" and thereby get as much weight as possible on the wheels. The plane can withstand a wheel loading of about 15,000 pounds on each tire, and can be braked to a full skid at a top speed of 150 mph. The B-26 is raced down the runway and braked by the pilot at predetermined speeds. When brakes are applied at 100 mph, the B-26 skids at approximately 146 feet per second. The rubber on the tire melts; grip on the concrete runway is lost. After five or six 300-foot skids, the tread rubber wears down to the casing. Skid forces and other test data obtained from strain gages, electronic measuring equipment, and high-speed motion picture cameras are analyzed and relayed to aircraft landing-gear designers.

In addition to yielding data which will ultimately result in the landing gear of the future, the tests are providing information on how aircraft tires stand up under high-speed landings. That information is expected to help the nation's tire manufacturers improve not only airplane tires but automobile casings as well.

Torque Converter Transmission

... recent design includes automatic gearshift and fluid drive at all times, with low rear axle ratio

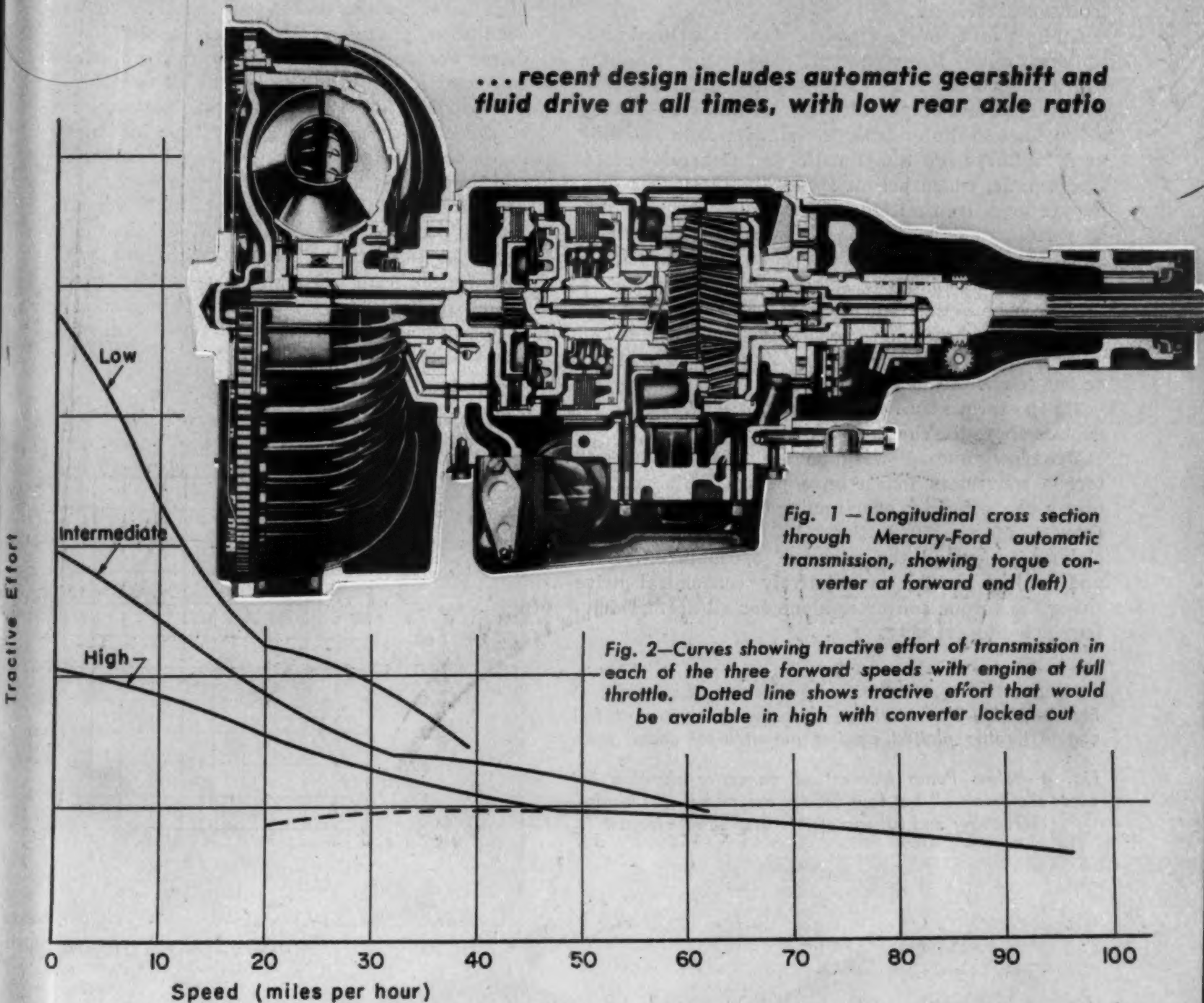


Fig. 1 — Longitudinal cross section through Mercury-Ford automatic transmission, showing torque converter at forward end (left)

Fig. 2—Curves showing tractive effort of transmission in each of the three forward speeds with engine at full throttle. Dotted line shows tractive effort that would be available in high with converter locked out

By Colin Carmichael
Editor, Machine Design

THERE is no standard, best way to accomplish an engineering result. Different engineers, working with the same basic principles and components, will come up with different solutions, all of comparable merit. Nowhere is this better illustrated than in the current designs of passenger-car torque-converter transmissions. With the introduction of the Mercury-Ford automatic transmission late last year there are now available five such units, all different although using similar basic elements.

This article is principally concerned with this new transmission and the engineering thinking behind its design. However, it should be of interest to provide additional background by first reviewing the fundamental similarities and differences between the five transmissions.

TRANSMISSIONS COMPARED: The four previous torque converter transmissions—Buick's Dynaflow, Packard's Ultramatic, Chevrolet's Powerglide, and the Studebaker—were illustrated and briefly discussed in the April, 1950, issue of MACHINE DESIGN. Each transmission has two more or less independent

units—a hydraulic torque converter and a change-speed gearbox. How these two units are designed, how they are combined to give a complete drive, and how the speed changes are controlled constitute the essential differences.

All hydraulic torque converters are capable of multiplying torque by virtue of stationary elements which absorb the reaction due to the differences between input and output torques. In this respect they differ fundamentally from the simpler fluid coupling used in Chrysler's Simplimatic and General Motors' Hydramatic, which permit speed differences but cannot change transmitted torque. However, torque converters used in present-day cars can function as fluid couplings whenever the output torque equals the input. This is the result of mounting the stator or reaction element on an overrunning clutch which permits it to be dragged around with the input and output elements at speeds above the "clutch point" or one-to-one torque ratio speed. Such a feature prevents the torque converter from effecting a torque reduction above the clutch point.

Dynaflow and Powerglide employ "polyphase" torque converters which have pumps with two elements connected by overrunning clutches (MACHINE DESIGN, March, 1948, Page 122). This feature is claimed to extend the range of optimum efficiency and makes possible a relatively economical drive using the torque converter alone for all normal driving, including cruising.

Ultramatic, Studebaker and Ford torque converters are simple, single-stage units. Ultramatic has four elements, Studebaker and Ford have only three. To improve economy at cruising speeds, Ultramatic and Studebaker bypass the torque converter under these conditions, giving a straight mechanical one-to-one drive. For reasons discussed later, Ford retains the converter in the power circuit at all times.

Gearboxes employed with torque converters are all of the constant-mesh planetary type in which shifting is done by hydraulically actuated friction clutches and brakes. Although manual controls on all present designs provide only Drive, Low and Reverse operating ranges, two of them—the Studebaker and Ford—employ three forward speeds with automatic shifting between high and intermediate. The others have only two forward speeds with a single normal driving ratio, relying entirely on the torque converter for speed and torque changing in Drive range. In the

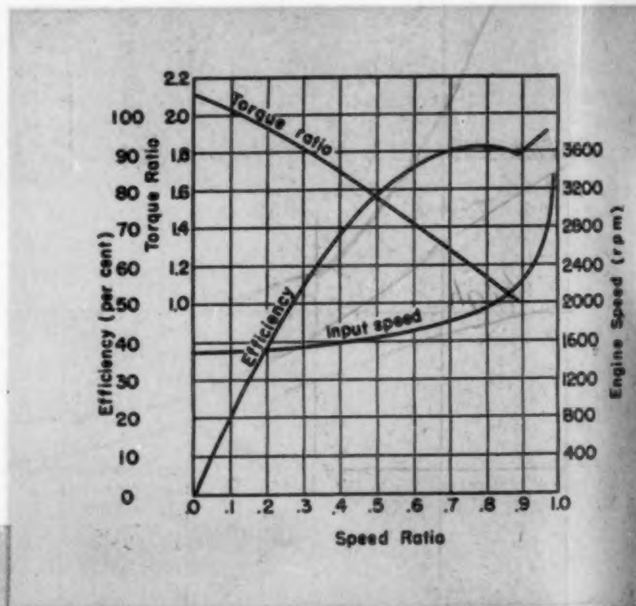
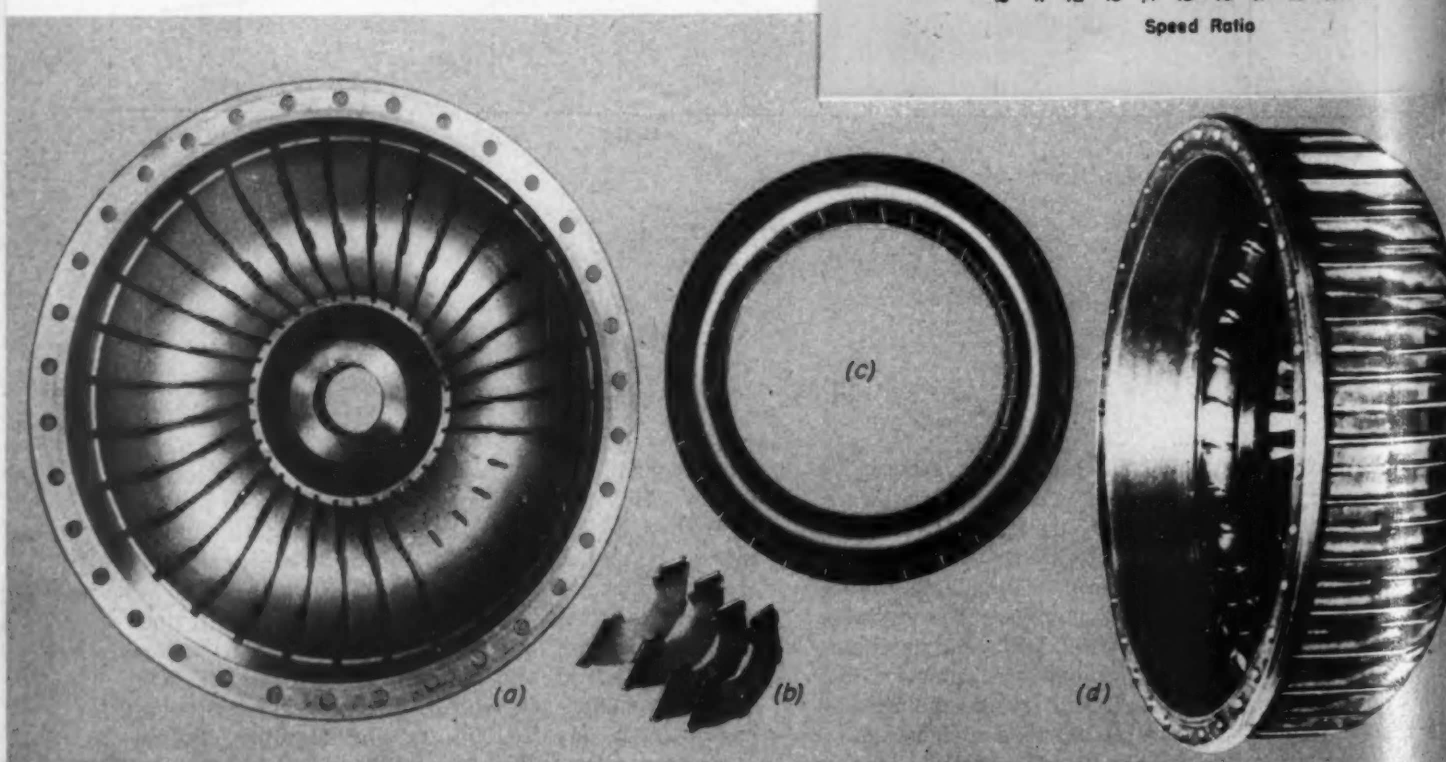


Fig. 3—Right—Characteristics of torque converter at full engine throttle plotted against output/input speed ratio

Fig. 4—Below—Pump element of converter showing (a) outer shell with all but four blades assembled, (b) blades, (c) torus ring and (d) completely assembled element



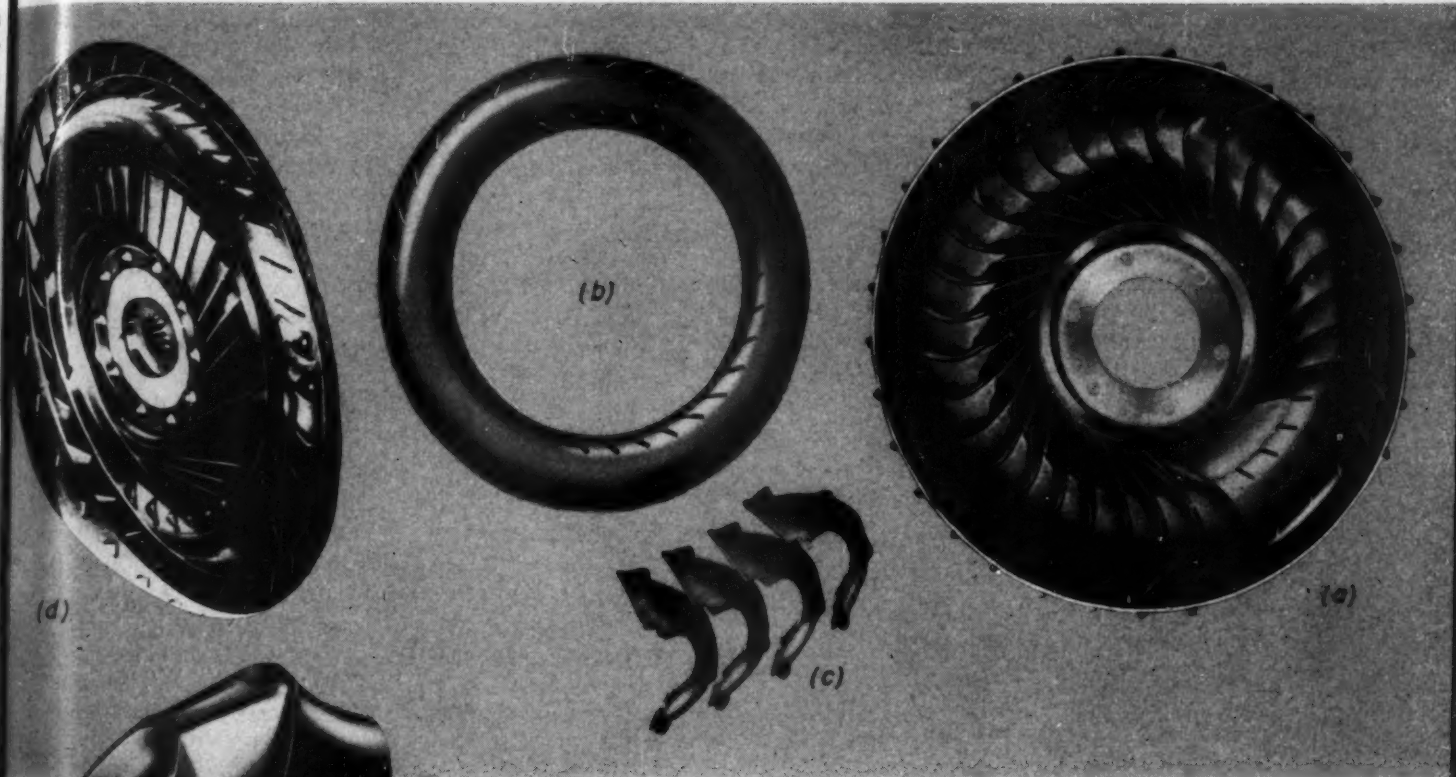


Fig. 5—Top — Turbine element of converter showing (a) outer shell, (b) torus ring, (c) blades, and (d) assembled element

Fig. 6—Above—Stator element of converter, an aluminum diecasting with a welded steel shroud ring

Low range the gearboxes in all five designs provide a manually selected emergency low.

MERCURY-FORD TRANSMISSION: Designed by engineers of the Borg-Warner Corp. and the Ford Motor Co., the new transmission, *Fig.* 1, was under development for about 4½ years. Principal design objectives, established after careful study of the operating characteristics of previous, successful automatic transmissions included the following:

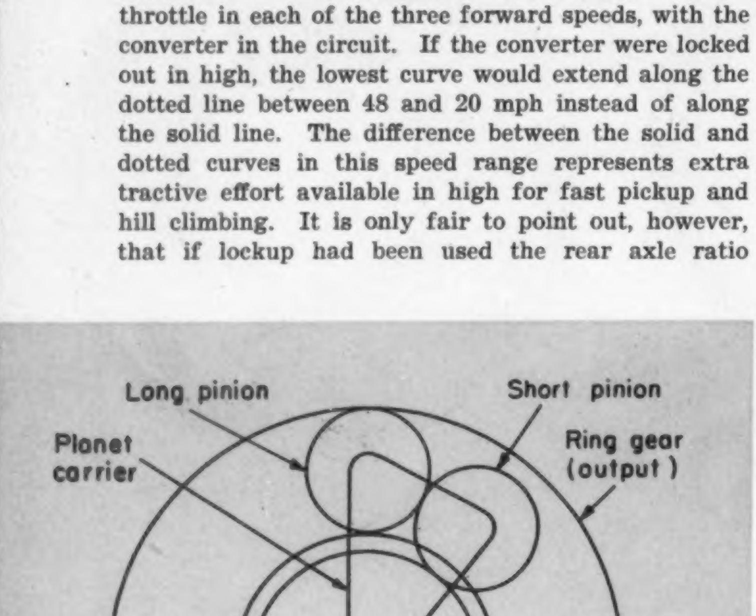
1. Overall spread of torque ratios to be adequate for all tractive effort requirements and to permit reduced engine rpm for cruising
2. Torque converter to have minimum slip when operating as a fluid coupling
3. Smoothness and flexibility of torque converter drive to be retained in high gear
4. Automatic power circuit to provide acceleration equivalent to second-gear start of a four-speed transmission.

First and last objectives were met by employing a three-speed gearbox with relatively low rear-axle ratio (3.31) and torque converter stall-torque ratio (2.1). Of the three gearbox speeds only two (high and intermediate) are automatically controlled, but the intermediate ratio (1.48) in conjunction with the torque converter and rear axle gives an overall starting ratio of $1.48 \times 2.1 \times 3.31 = 10.29$ between engine and wheels, which drops to $1.48 \times 3.31 = 4.90$ when the torque converter acts as a coupling. This provides the acceleration characteristics specified in the fourth objective, giving fast pickup without "jackrabbit" characteristics.

Second objective was met by employing a simple three-element torque converter of reasonable stall ratio (2.1) which has high efficiency in the coupling range. An alternative design with a higher ratio was tested and proved satisfactory with a two-speed gearbox even when starting in high with only the converter (2.27) and rear axle (3.5) torque multiplications between engine and wheels. However, this alternative design had a higher slip when operating as a coupling; for example, at 60 mph and road load the slip was 5¼ per cent compared with 2½ per cent for the design actually adopted. The difference in engine speed corresponds to a difference of 4 friction horsepower, resulting in ¾ to 1 mile per gallon fuel consumption difference in favor of the production transmission.

Third objective was equivalent to specifying no lockup of the torque converter in high gear. As indicated in the foregoing, the slip of the torque converter is low when it operates as a coupling, which

it does at road loads, hence the road-speed economy is satisfactory without bypassing the converter. At the other end of the range, retention of the converter in the automatic range provides extra "zip", as ***Fig.*** 2 shows. The curves illustrate tractive effort at full throttle in each of the three forward speeds, with the converter in the circuit. If the converter were locked out in high, the lowest curve would extend along the dotted line between 48 and 20 mph instead of along the solid line. The difference between the solid and dotted curves in this speed range represents extra tractive effort available in high for fast pickup and hill climbing. It is only fair to point out, however, that if lockup had been used the rear axle ratio



Condition	Input	Stationary	Ratio
Neutral	None	None	0
Low	Rear sun	Planet carrier	2.44
Intermediate	Rear sun	Forward sun	1.48
High	Both sun	None	1.00
Reverse	Forward sun	Planet carrier	— 2.00

Fig. 7—Schematic diagram of planetary gearset. Actual transmission employs three pairs of planet pinions

would have been higher, which would have placed the high-gear tractive effort curve somewhere between the solid and dotted curves.

Within the foregoing design framework have been added control features to take advantage of the inherent torque converter and gearbox characteristics under all conditions of speed and load. For example, in normal driving with the manual control set at Drive, starting is always in intermediate gear with an automatic shift to high at some speed between 17 and 63 mph depending on engine throttle opening; the wider the throttle opening the higher the speed at which upshift occurs. Downshift from high to intermediate is effected by pressing the accelerator pedal beyond the wide-open position at any speed between 57 and 20 mph. Below 20 mph the downshift occurs at less than full throttle and at 5 to 8 mph downshift occurs with closed throttle.

Low gear is intended to meet extreme demands for acceleration, hill climbing, or hill braking. Manual control set to Low places the gearbox in low ratio (2.44) at less than 25 to 30 mph. Above 25 to 30 mph the Low setting places the gearbox in intermediate ratio (1.48) regardless of throttle opening. Such a combination of ratios is desirable in some parts of the country both for up and down grades. The shift between Drive and Low ranges may be effected under torque at any speed and throttle.

TORQUE CONVERTER: Some of the torque converter design requirements have already been touched upon. Other design requirements were:

1. Engine speed to rise with car speed, a characteristic which permits reasonable stall speed (about 1500 rpm engine speed at full throttle) coupled with torque conversion to a reasonably high car speed (about 48 mph in high gear)
2. High converter efficiency above 0.5 speed ratio, to provide economy even in city driving
3. Integral air cooling.

Performance curves for the torque converter at full engine throttle are shown in ***Fig.*** 3. The abrupt change in the efficiency curve at about 0.89 speed ratio occurs when the torque converter ratio becomes unity and the stator element starts to freewheel with the pump and impeller. Above this speed ratio the converter acts as a fluid coupling, the torque ratio remains one, and efficiency rises with speed ratio.

The assembled torque converter is shown at the left-hand or forward end of the complete transmission, ***Fig.*** 1. It consists of the usual pump element driven from the engine through a flexible plate for vibration isolation, a turbine element splined to the gearbox input shaft, and a stator element supported by the housing on an overrunning clutch.

In the selection of materials and processes for making the torque converter elements a dominant consideration was the intended application to the highly competitive low-priced field, which made cost a vital factor. At the same time, manufacturing techniques adopted for economy's sake could not be permitted to interfere with the performance desired in a higher-priced design. When each element was analyzed in this light, the results showed that no one process proved to be the best for all three elements.

The impeller or pump element is an aluminum die-casting with 31 stamped blades inserted into slots, ***Fig.*** 4. Initial considerations were the need for a large number of cooling fins as an integral part of the outer shell, ***Fig.*** 1, plus the desirability of quietness in operation, particularly with respect to hydraulic noise at stall and low speed ratios. Need for integral fins dictated a casting process, with aluminum the material for light weight and satisfactory noise damping.

It was found that casting the internal blades in-

tegral with the outer shell would require the use of sand or plaster molds, at prohibitive cost. Accordingly it was decided to use separate stampings for the blades, steel being selected for its strength and rigidity. Each blade requires four slots in the shell to position it and to transmit torque, a total of 124 slots for the 31 blades in each converter. These slots have to be closely controlled for position as well as for width and depth dimensions. Machining being too costly, the slots had to be cast and only a die-casting gave required accuracy at reasonable cost.

The turbine, *Fig.* 5, is an assembly of steel stampings the outer shell of which is riveted to a forged steel hub. The 33 blades are located in the outer shell by four tabs extending from the blade through the shell and held in place by bending the tabs. The torus ring is slipped into place over the two remaining tabs on each blade, which are bent over by rolling.

In the construction of the turbine two processes were considered as production possibilities—a one-piece plaster-mold casting, or an assembly of steel stampings. The stamped design proved to have a decided edge costwise over the alternative process. It is noteworthy that while considerable effort was required to develop the production processes and tooling for the three-dimensional twists of the turbine blades, the actual assembly of blades and shells is relatively simple—in fact, much less of a problem than was anticipated.

Originally the turbine assembly was copper brazed, blade tabs and slots being used for positioning during brazing. This eliminated the need for complicated and highly perishable brazing fixtures. However, early in the experimental program it was found that a brazed joint of a single-thickness blade edge at right angles to the inner and outer shells was not sufficiently reliable to be considered adequate. It was necessary to have a tab or equivalent means of obtaining intimate contact and additional area for the brazed joint at all critical points.

Inasmuch as the tabs were already relied on for the major part of the strength consideration it was decided to eliminate the brazing operation and utilize only the tabs. After some redesign of the assembly, increasing the size of the tabs and adding fillets at the corners of the tabs, this method was found to be quite satisfactory. While the tab and slot assembly may not be quite as rigid as a copper-brazed design, tests on many units approaching a total of one million miles have been run without failure, indicating a highly acceptable durability.

The stator or reaction member, *Fig.* 6, is an aluminum diecasting on which a formed split steel shroud is assembled and retained by welding at the split. While the airfoil-shaped blades which the diecasting process makes possible give slightly improved performance over single-thickness stamped blades, the

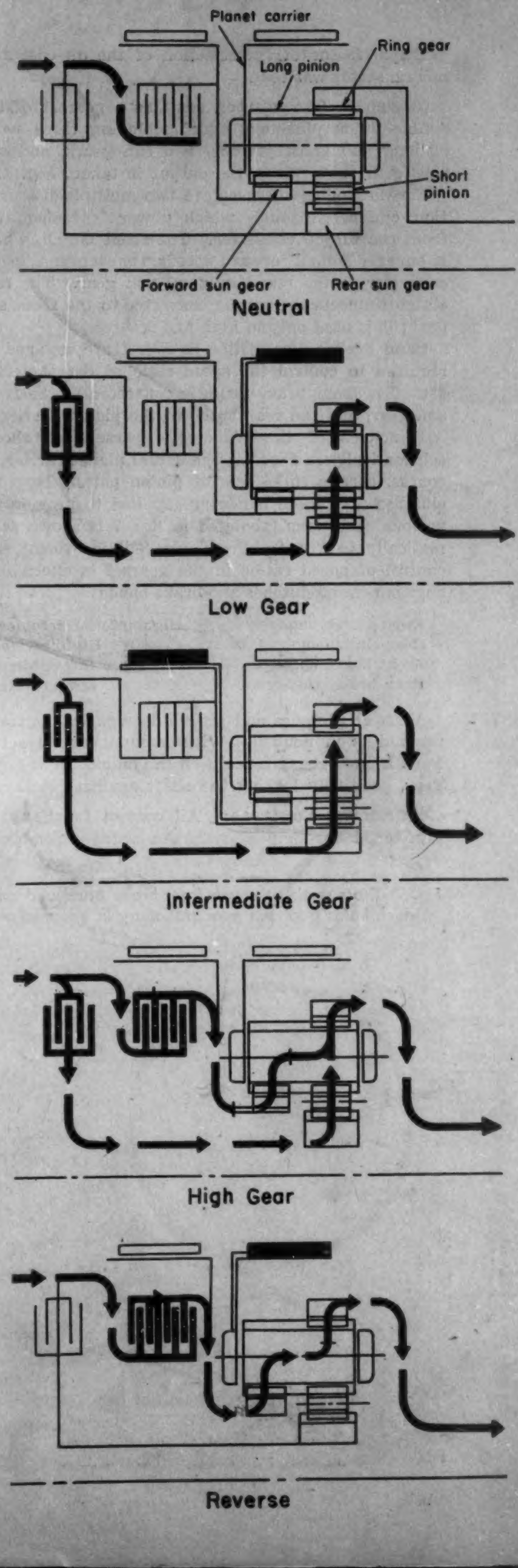


Fig. 8—Power flow through gearbox in each gear, showing how clutches and brake bands are engaged or released to give the conditions indicated in Fig. 7

principal factor in the selection of the die-cast aluminum stator was cost.

GEARBOX: The gearbox contains a gearset of the double-pinion planetary type employing three pairs of long and short pinions, two sun gears, and one ring gear from which the output is taken, *Fig.* 1.

Forward of the gearset are two multiple-disk friction clutches through which power is transmitted from the torque converter. The front clutch, which is engaged for all forward speeds, connects the torque converter to the rear (smaller) sun gear. The rear clutch connects the torque converter to the front sun gear; it is used only in high and reverse.

Band brakes also visible in *Fig.* 1 are engaged as required to control the speed ratio of the planetary set. The front brake drum is connected to the front sun gear, and the rear brake to the planet carrier.

Principles of the planetary gearset are shown schematically in *Fig.* 7. The actual planet carrier, of course, carries three sets of pinion pairs. How the clutches and brake bands are applied to provide the various conditions tabulated in *Fig.* 7 is shown schematically in *Fig.* 8. From *Fig.* 8 it is evident that control of speed ratios in the gearset is effected by engagement of clutches and brake bands:

Front clutch engaged	High, intermediate, low
Rear clutch engaged	High, reverse
Front brake engaged	Intermediate
Rear brake engaged	Low, reverse

With all clutches and brakes disengaged the transmission is in neutral. With manual control set to Park a pawl engages teeth on the outside of the ring gear, positively locking the shaft against rotation.

AUTOMATIC CONTROLS: All control functions are performed through a hydraulic valve assembly in conjunction with a centrifugal hydraulic governor on the output shaft. Automatic shift between high and intermediate is effected through a valve which is subject to opposing pressures on its opposite ends—governor pressure proportional to car speed and another pressure proportional to engine throttle opening. When governor pressure overcomes throttle pressure because of increased car speed or decreased throttle opening, the valve shifts, admitting oil pressure to engage the rear clutch and at the same time releasing the front brake band, *Fig.* 9. This puts the gearset into high, *Fig.* 8. When differential pressure acts the other way the resulting valve movement puts the gearset into intermediate.

The valve assembly which regulates pressure according to throttle opening is connected through an external linkage to the throttle control. In addition to acting on the shift control valve this pressure also acts upon a compensator valve which modulates the main control pressure to maintain torque capacity of clutches and brake bands according to engine output.

Another valve regulates low servo pressure to soften the engagement of the low band on the shift from drive to low range. Still another valve, known as the low inhibitor, is subject to governor pressure and above 25 to 30 mph keeps the transmission from shifting into low ratio even when the manual control is set to Low.

MATERIALS: In the transmission extensive use has been made of aluminum diecastings, of which there are 24 including four in the converter. Parts so made include the highly intricate valve bodies, the governor body, the rear pump body, brake servo cylinders and pistons.

Transmission gears are high carbon alloy steel heat treated so as to give a tough core and a light, file-hard case; pinion pins are induction hardened SAE 1085 to give proper hardness depth for the needle bearings and still maintain softness at the ends for staking in assembly. Valve spools are SAE 1112 steel, carburized.

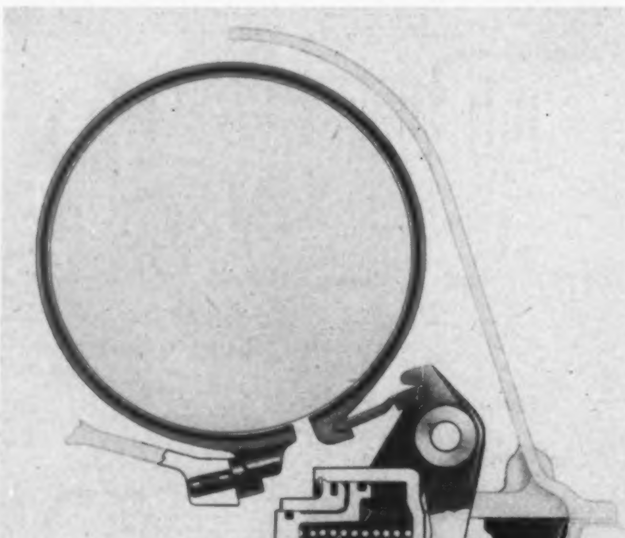
Pinion carrier and rear brake drum are of two-piece cast iron construction. Little machining being necessary, cost is low; also, the cast iron provides a highly satisfactory braking surface.

Front brake, *Fig.* 9, uses a woven facing cemented to the steel band; rear brake, because of the high imposed torque in reverse (about six times engine torque) employs a 0.050-inch thick semimetallic friction facing cemented to the steel band. Multiple disk clutches have alternate sintered bronze and steel plates.

Partly as a result of the extensive use of aluminum diecastings the total weight of the automatic transmission has been held to only 77 pounds over that of the standard transmission.

Much of the basic information in this article is from an SAE paper by Harold T. Youngren, vice president, engineering, and H. G. English, assistant research engineer, Ford Motor Co. Additional information furnished by Ford Motor Co. through the courtesy of N. L. Blume, technical assistant to vice president, engineering and V. J. Jandasek, research engineer, is gratefully acknowledged.

Fig. 9—Cross section through front brake band and servo, which holds front sun gear stationary in intermediate



Design Factors for Stress Concentration

Part 1—Notches and Grooves in Bending

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Westinghouse Electric Corp.
East Pittsburgh, Pa.

CHANGE of contour of a bar or shaft due to a notch, fillet, thread, or groove causes a local stress peak, as shown in *Fig.* 1. For design purposes a *stress-concentration factor* is used to express the ratio of this maximum stress to the nominal stress, $K_t = S_{max}/S$. Nominal stress, S, is given by the conventional formulas, P/A, Mc/I or Tc/J, for axial, bending or torsional loading, respectively.

In a series of data sheets, of which this is the first, stress-concentration factors will be given in graphical form and their application in design discussed. Data will be given for the cases of notches, grooves, fillets, and transverse holes subjected to axial, bending or torsional loading. The curves are part of a series which has been used in design work at Westinghouse for a number of years; some were used by government design departments during World War II.

PROCEDURE: The strength of a member depends not only on the shape (stress concentration) but also on the material (brittle or ductile) and loading (static or variable). Distinction between brittle and ductile materials is arbitrary; sometimes an elongation of 5 per cent is considered to be the dividing line.

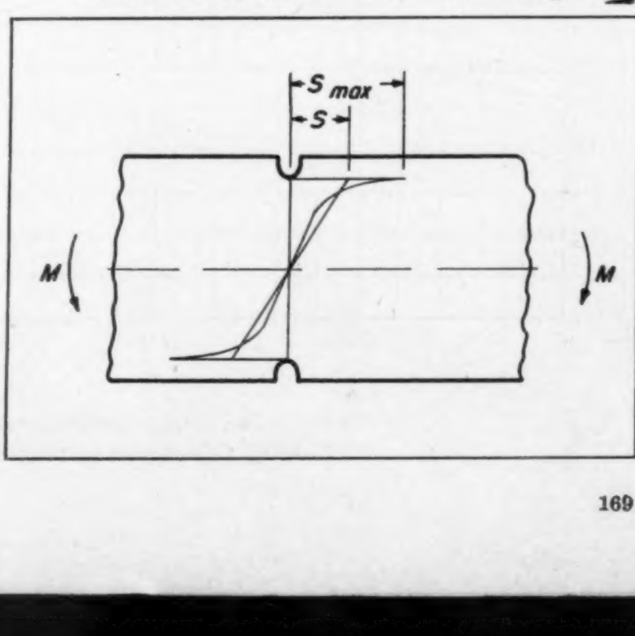
Brittle Materials: With notched flat bars and grooved shafts, for either *static or variable loading,* use K_t, *Figs.* 2 and 3. This corresponds to both the maximum stress theory and the Mohr theory of failure for this case[1].

Ductile Materials: For *static loading,* use $K_t = 1$ (no stress-concentration effect). If a part is loaded statically but may also be subjected to shock loading, or if the part is to be subjected to low or high temperature, or if the part contains sharp discontinuities, a "ductile" material may behave in a brittle manner[2, 3, 4]. If there is any doubt in such special cases, K_t from *Figs.* 2 and 3 should be applied. For *variable (cyclic) loading* of grooved shafts, use K_t', *Fig.* 4. This corresponds to the shear-energy theory[5]. For flat pieces, use K_t from *Fig.* 2 which is applicable for both strength theories since the stress condition is uniaxial.

A variable stress that is not completely alternating can be considered to consist of a steady component and an alternating component. It is usual practice in the design of ductile members to apply the K_t or K_t' factor to the alternating component only[5].

It is well known that materials vary in *notch sensitivity* and that very small notches and grooves have less damaging effect in fatigue than would be pre-

Fig. 1—Comparison of nominal and actual stresses at critical section of notched bar in bending



Curve sheets appearing in this article together with additional design data will appear in a forthcoming book to be published by John Wiley & Sons Inc., New York.

[1] References are tabulated at end of article.

Data Sheet

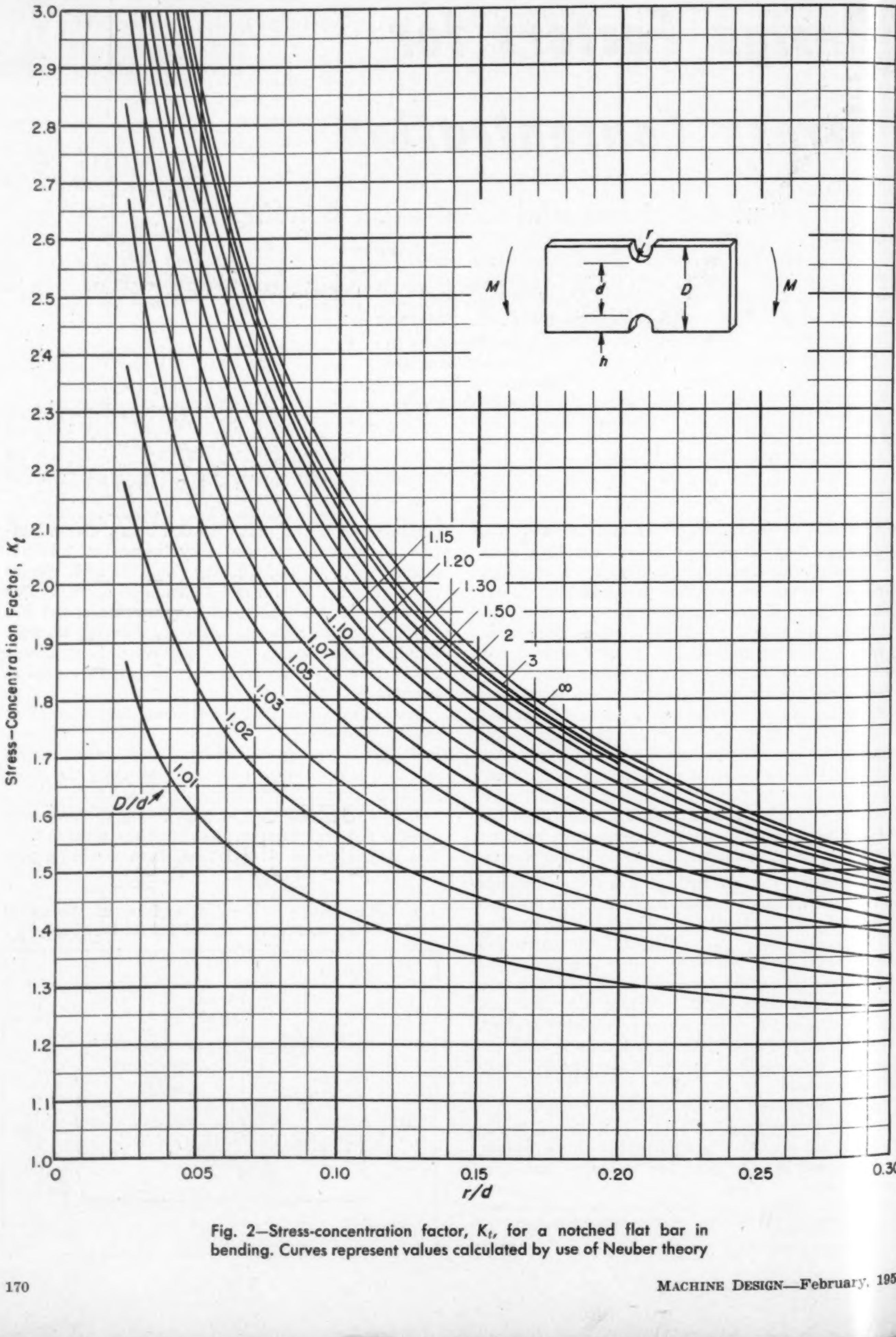


Fig. 2—Stress-concentration factor, K_t, for a notched flat bar in bending. Curves represent values calculated by use of Neuber theory

Stress Concentration

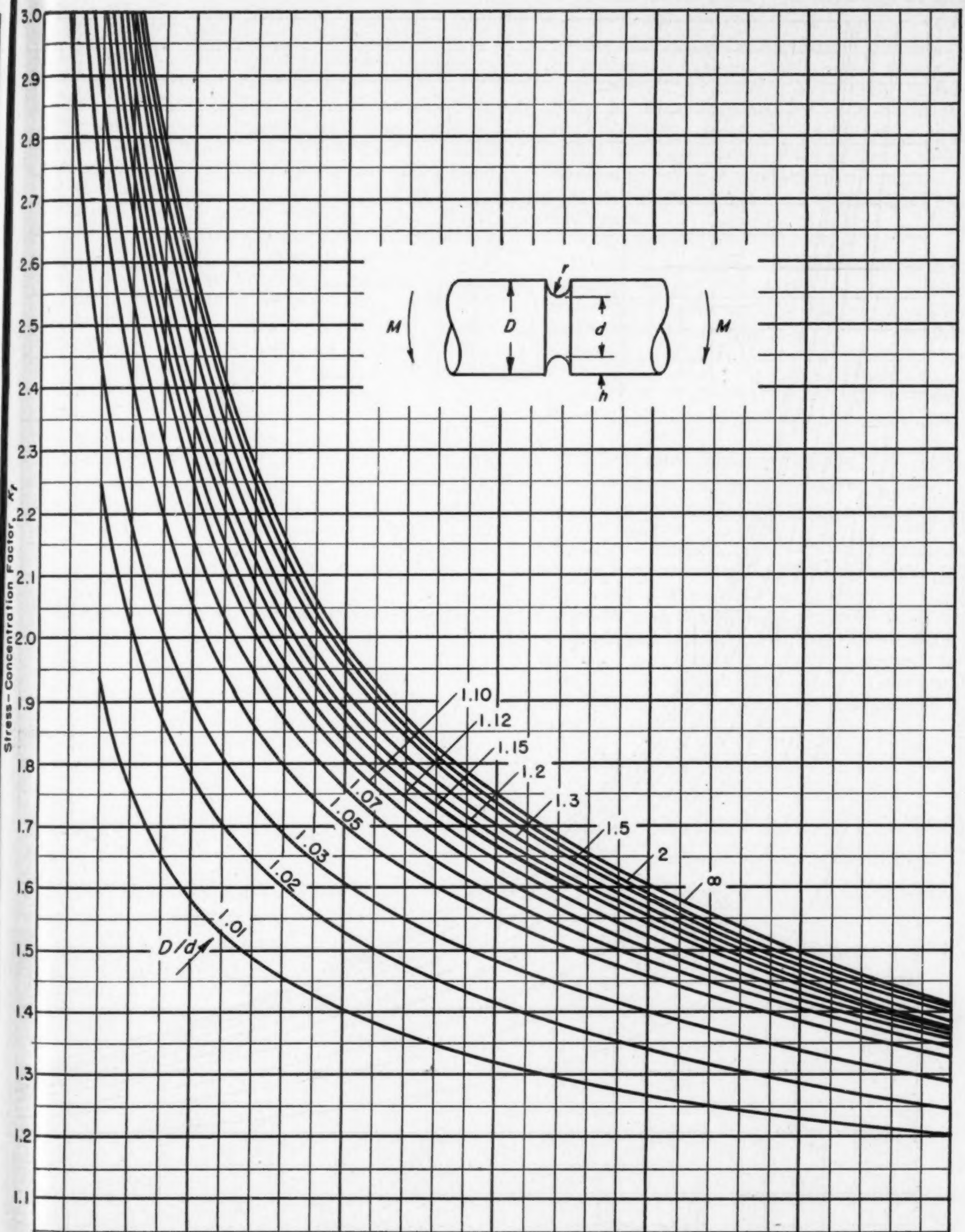


Fig. 3—Stress-concentration factor, K_t, for a grooved shaft in bending. Curves represent values calculated by use of Neuber theory

Data Sheet

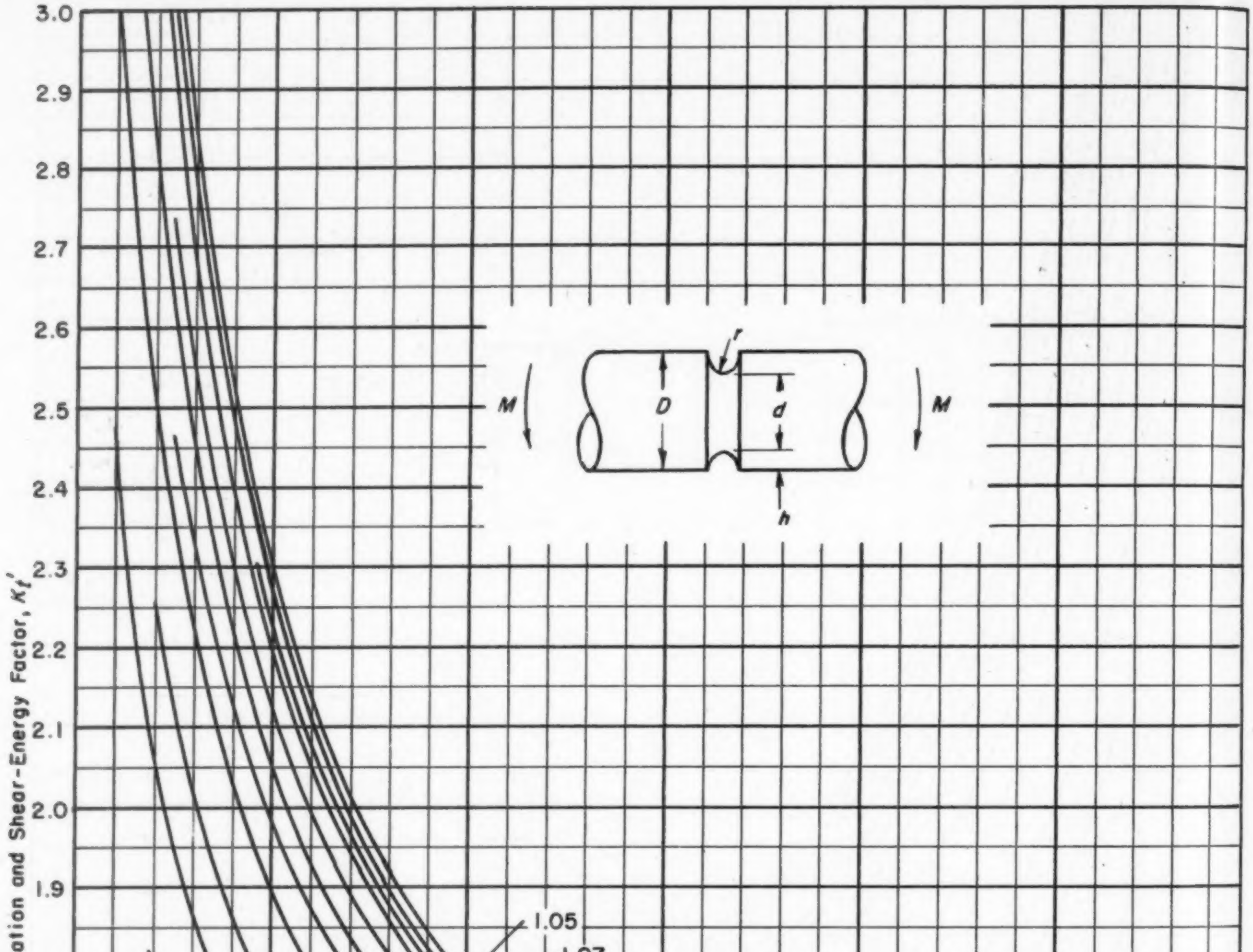


Fig. 4—Combined stress-concentration and shear-energy factor, K_t', for a grooved shaft in bending. Factor $K_t' = mK_t$ where m = factor for shear-energy theory of failure

dicted by the theoretical factors. To take account of this, a *fatigue-notch factor* is sometimes used, defined as follows[6]: $K_f = 1 + q\,(K_t' - 1)$.

Notch sensitivity, q, is obtained[7] from *Fig.* 5, which gives average values for two broad classes of steels. There is some evidence[8] that the q curve for aluminum alloy sheet is lower than the curves of *Fig.* 5, but this is not well established. From *Fig.* 5 it can be seen that the q factor is of significance only for small radii—less than 1/32-inch for heat-treated alloy steels and less than ⅛-inch for annealed or normalized steels. Note that *Fig.* 5 is not valid for extremely deep sharp notches or grooves which, incidentally, should be avoided in critical load-carrying members. Note also that if the factor is not used at all (data are not available for many materials) the resulting design "error" will be in the safe direction.

ORIGIN: Values plotted in *Figs.* 2, 3 and 4 have been calculated in accordance with the theoretical work of Neuber[9]. The top curves of *Figs.* 2, 3 and 4 correspond to deep hyperbolic notches (or grooves) and the bottom ones to shallow elliptical notches (or grooves). In between, the values represent an approximation based on both types of notch. However, it has been found that actual grooves used in machine parts, such as semicircular, "V" and straight-sided grooves (*Fig.* 6), are all fairly well approximated by *Figs.* 2, 3 and 4.

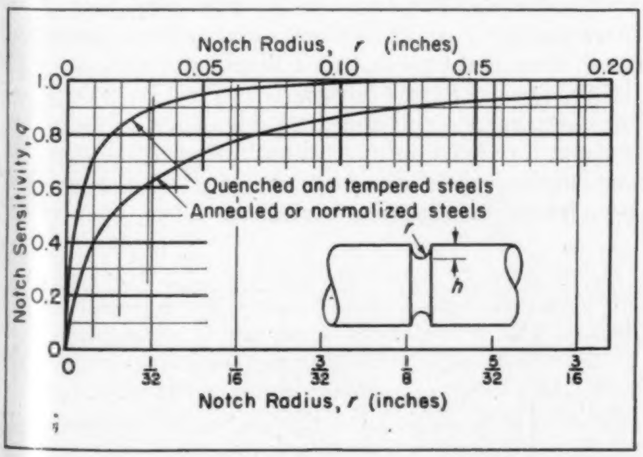
EXAMPLE: Determine the bending fatigue strength of the shaft shown in *Fig.* 6c for two materials: an axle steel (normalized 0.40 per cent carbon), and a heat-treated 3½ per cent nickel steel (SAE 2345). With no stress-concentration effect these materials have endurance limits of approximately 30,000 and 70,000 psi, respectively, when tested in the conventional manner[6] in a rotating-beam machine.

First, find K_t'. From *Fig.* 6c, $D = 1.378$ inch, $d = 1.253$ inch, $r = 1/32$-inch. Then, $D/d = 1.10$ and $r/d = 0.025$. From *Fig.* 4, $K_t' = 2.65$.

From *Fig.* 5, for $r = 1/32$-inch q values of 0.63 for the axle steel and 0.90 for the heat-treated alloy steel are found. By substitution in the formula for fatigue-notch factor, $K_f = 1 + 0.63\,(2.65 - 1) = 2.04$ for the axle steel and $K_f = 1 + 0.90\,(2.65 - 1) = 2.49$ for the alloy steel. The fatigue strengths are $S_f = 30{,}000/2.04 = 14{,}700$ psi for the axle steel and $S_f = 70{,}000/2.49 = 28{,}100$ psi for the heat-treated alloy steel.

These are the expected strengths of the shaft, *Fig.* 6c, under fatigue for the two materials given. These are not working stresses, since a factor of safety must be applied. Depending on type of service, consequences of failure, experience, etc., different factors of safety are used throughout industry. The strength of a member, however, is not a matter of opinion or judgment and should be determined in accordance with the best methods available. Naturally, test of the member is desirable whenever possible. In any event, the initial calculation should be made with the best available methods and should include all known factors.

Fig. 5—Average notch-sensitivity factors for two classes of steel. Curves are not valid for h/r values greater than 3



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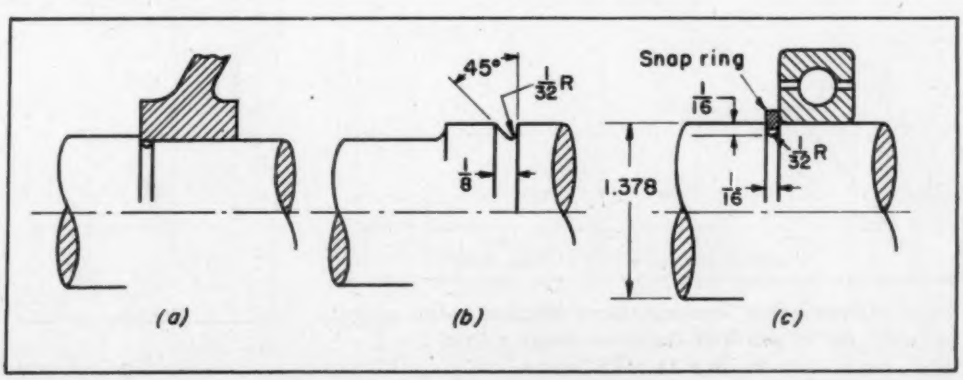


Fig. 6—Examples of grooved shafts. A grinding relief groove is shown at *(a)*, an oil slinger groove at *(b)*, a snap ring groove at *(c)*

DESIGN ABSTRACTS

Temperature Rise in Electronic Equipment Cases

By Robert J. Bibbero
Bell Aircraft Corp.
Buffalo, N. Y.

IN THE design of reliable electronic equipment it is necessary to estimate the average temperature rise above ambient before making a final choice of case configuration. This step is necessary to insure that no component will be subjected to more than its rated ambient temperature. In airborne electronic equipment, temperature rise considerations are even more important because of the increasingly high degree of miniaturization, accompanied by a decrease in heat dissipating area, and because of the marked reduction in cooling capacity of low pressure air.

The equilibrium temperature rise of any heat dissipating equipment is dependent on the rate of heat production in the equipment and its ability to dissipate that heat per unit temperature difference. The rate of heat loss is the summation of the dissipation by each of the three modes: conduction, convection, and radiation. Since the efficiency of each mode is dependent on a different function of the temperature difference, Δt, it is usually only possible to arrive at a solution for Δt by trial and error calculation. To simplify this problem, calculations have been made for the several modes and the results combined into a graphical solution. The charts of *Figs.* 1 and 2 give approximate values that are useful for most applications.

Temperature rise, Δt, for cases of different areas at sea level is given by the graph in *Fig.* 1. Since heat dissipation varies with pressure, an altitude correction is necessary. To obtain the Δt at any altitude corresponding to a given power rating, first find the sea level power by dividing actual dissipation by the altitude factor in *Fig.* 2. Use this equivalent power to find Δt in *Fig.* 1.

To correct deviations from the assumed emissivity, a correction must be made for each surface condition. A highly reflective aluminum surface approximately doubles the temperature rise over that of a black surface. At 40,000 feet, an aluminum case may have three times the Δt of a black case at sea level.

The effect of well-designed louvers is to reduce the temperature rise shown in *Fig.* 1 by as much as one-third at sea level. At high altitudes, the density and hence volumetric heat capacity of the air so transferred is lessened; hence, the effect of louvers

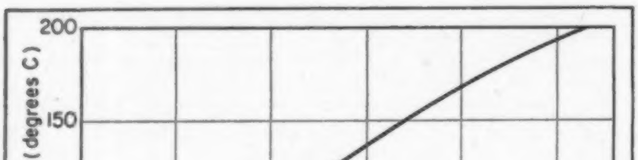


Fig. 1—Temperature increase above ambient versus power per unit area at sea level for cases ranging from 2 x 2 x 1 to 18 x 18 x 18 inches

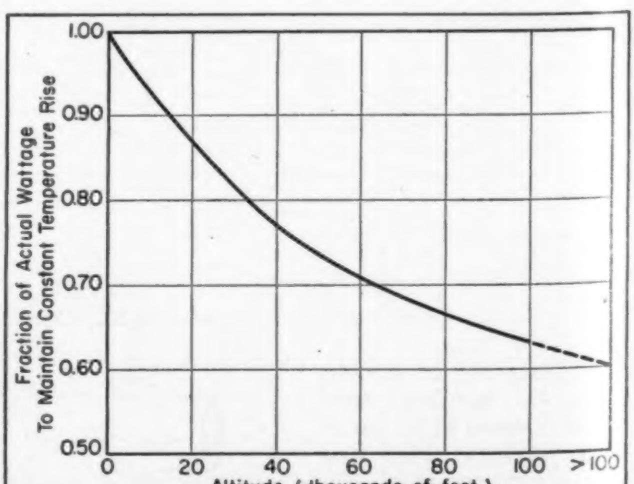


Fig. 2—Correction factor for altitude

is reduced. Approximate deductions from the Δt of *Fig.* 1 for several altitudes are 33 per cent at sea level, 15 per cent at 20,000 feet, 6 per cent at 40,000 feet, and none at 100,000 feet.

For ambient compartment temperatures greater than 25 C, the Δt is somewhat higher since warm, less-dense air has lower cooling capacity. From 10 to 50 C, the Δt increases about 10 per cent. Increased compartment temperatures may result from the high skin temperature of high-speed aircraft and missiles. Calculations show that little reliance can be placed on the low ambient temperatures at altitude for cooling equipment in high-speed aircraft because of high skin temperature.

From a paper entitled "Estimating Temperature Rise in Electronic Equipment Cases," presented at the Dayton Conference of the Institute of Radio Engineers, May 5, 1950.

Partners in Research

By C. C. Furnas
Cornell Aeronautical Laboratory Inc.
Buffalo, N. Y.

KNOWLEDGE breeds new knowledge and research brings forth an ever-increasing flood of new ideas. Hence, if allowed to follow in its own way, the course of research is like a fire—the faster it goes, the hotter it gets and, hence, the faster it goes. Inevitably in such an environment the simpler tasks are accomplished first and there is an ever-increasing complexity along with increasing volume. The obvious result of this trend toward complexity has been to increase not only costs, but the number of specialists, the number of people, and the number of discrete teams that are involved in carrying any new steps of applied science to a useful fruition. It is highly desirable—particularly in times of national emergencies—to take a close look at the possible effectiveness of directing or at least guiding our group efforts.

Although it is not possible to set up hard and fast lines, it is generally conceded that the activities which are associated with doing new things are roughly of three different kinds: fundamental research, applied research, and development.

Fundamental research in the sciences is that type of investigation which adds to our knowledge of the working of the natural laws. In its pure form this usually consists of theoretical work and measurement of physical quantities. There is a side branch of this activity which is often called *exploratory research*—that activity where the scientist takes a quick look at something to try out an idea. It is usually empirical and often qualitative. It may be entirely the approach of the inventor rather than that of the rigid scientist.

Applied research is the pursuit of a planned program toward a definite practical objective. The desired end result is predetermined. It takes the results of fundamental or exploratory research and tries to apply them to a specific process, material or device. Applied research usually carries an investigation up to the point of the first successful working model of a mechanical or electrical device, or through the usual glassware stage in a chemical synthesis. If an applied research program is successful, it has demonstrated that a certain thing is possible to achieve.

Development is the activity wherein the results of applied research are taken in tow and the item in question is engineered, demonstrated, evaluated, and thoroughly tested. It may be said that the development phase demonstrates that something which has previously been proven possible is definitely feasible for production and use.

In the practical sense research activities have not come to the point of justifying their existence until production and use have been realized. Only then does the process of doing something new come of age. Consciously or unconsciously, and whether organized or not, all the usable developments of the modern world go through this process of exploration, applied research and development before production is an accomplished fact.

Be it emphasized, however, that the value of research in the pattern of civilization is not confined to these utilitarian objectives. Fundamental and exploratory research has great virtue by itself and is essential for any progressing civilization. Enlarging of the knowledge of the natural world has great impact upon the average man's concepts and his pattern of thought, and these are intangibles which are fully as important as the mechanical gadgets and processes which we associate with applied research and development.

Each of the three principal categories of research is, on the average, a distinctly different type of activity than the other. It calls for different talents, approaches, type of mind, and frequently different types of equipment. There is variation in the background, objectives, the methods of operation, and even the language and concepts. Consequently, the different teams—even when well supplied with good will—frequently tend to operate at cross purposes and spend more time and effort in casting snide

". . . aura of the ivory tower . . . world does not understand . . ."

remarks and glaring at each other than in effective collaboration. This is the heart of the problem and there certainly is no simple answer.

The reasons for the ineffectiveness of collaboration are rooted in many areas, most of them dealing with

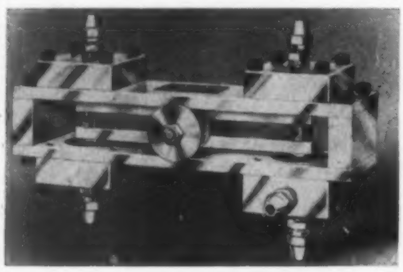
(*Continued on Page* 198)

NEW PARTS AND MATERIALS

... presented in quick-reference data-sheet form for the convenience of the reader. For additional information on these new developments, see Page 187

Ratio Totalizer Control 1

Hagan Corp. Pittsburgh, Pa.



Style: Mechanical balance beam, spring-loaded chamber (pneumatic), bellows chamber (fluid)

Size: Mounting space 10 x 8⅜ x 7½ in.

Service: Add, subtract, multiply, or divide control signals; beam arm ratios 1:1 to 16:1 (proportional band of 25 to 400% as regulator); air pressures 60 psi max with spring; fluid pressures 600 psi max with bellows; pilot valve output loading pressure ranges 3 to 15, 0 to 30 or 0 to 60 lb, 2 cfm capacity at mean load, air consumption 0.25 cfm

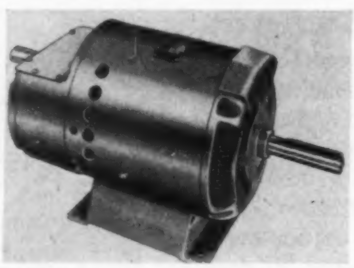
Design: Four pressure chambers in opposing pairs acting through nonmetallic flexible diaphragms on the two ends of the balance beam; poppet pilot valve communicating with one chamber regulates output pressure, movement of beam in response to input load in one of other three chambers opens valve until balance is restored; accuracy to 1% full-scale reading; loading pressure reproducible on change in input loading within 0.1% when output pressure is max

Application: For general process control, computing circuits or to introduce proportional band action and/or automatic reset in control circuits.

For more data circle MD 1, Page 187

Reversing Transmission 2

Vickers Electric Div., Vickers Inc., 1518 Locust St., St. Louis 3, Mo.



Style: Model 32D22 reversible transmission, foot-mounted

Size: ¼ to 10 hp range; 10 in. high 22 11/16 in. overall length including 3 in. input shaft and 3¾ in. output shaft of 1-in. diam., 10-in. wide at base, 9-in. diameter housing; weight 115 lb

Service: Max continuous duty ratings 2000 rpm, 85 C (40 C ambient) temperature rise of coils; on-off service, 32 lb-ft torque, 800 ampere-turns d-c coil excitation, 35 w coil power; slip service, 300 w slip dissipation, 9.5 lb-ft torque, 700 ampere-turns d-c coil excitation, 30 w coil power

Design: Reversible; separate excitation coils for adjustable torque output in both directions of rotation; gearing ratio, input shaft and contrarotating driving members, one-to-one; single, low-inertia driven member direct-connected to output shaft for reversing without backlash drive connection by means of two magnetic-particle clutches rotating in opposite directions.

Application: For reversible or reversing drives from unidirection input on machines.

For more data circle MD 2, Page 187

High-Speed Generator 3

General Electric Co. Small & Medium Motors Div., Schenectady 5, N. Y.

Style: Synchronous types ATI, ASI, and ATB

Size: 1.875 to 50 KVA

Service: 60 and 400 cycles; 2 kw single phase to 15 kw 3-phase (externally excited 60 cycle), 1 kw single phase to 10 kw 3 phase (self-regulated 60 cycle), 2 kw single phase through 15 kw 3 phase (amplidyne excited 60 cycle), 2 kw single phase through 40 w 3 phase at 3428 rpm (high frequency 400 cycle)

Design: ATI—3-phase amortisseur windings in pole face; ATB—3-phase without winding; ASI—single phase; basic 60-cycle unit is externally regulated and operates with standard voltage regulator in exciter field circuit with 64 or 125 v excitation; modifications of standard include self-regulated with special saturated magnetic circuit and overhung exciter or amplidyne excited with overhung exciter and static voltage regulator in package; high frequency unit is 14-pole.

Application: Standard units for range of voltage regulating and motor starting power requirements; high-frequency especially adapted to military ground power engine or m-g sets, textile drives.

For more data circle MD 3, Page 187

JOHNSON BRONZE

SLEEVE BEARING DATA

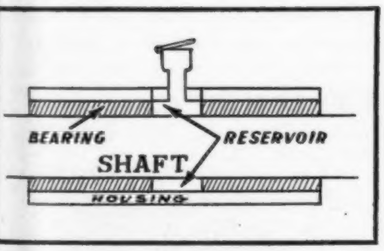
Bearing DESIGN

JOHNSON BRONZE

SLEEVE BEARING DATA

The Lubrication of Sleeve Type Bearings-2

NO BEARING, regardless of ype, will operate satisfactorily or for any ngth of time without proper and dependble lubrication. The lubricant, as the life lood of every motive unit, should be the rrect type, the right consistency and ways in the right place at the right time. therwise excessive heat, wear and friction ill develop with eventual seizure and earing failure. The most popular lubriating agent is oil, with grease in some pplications and graphite, water or other uids used to a lesser degree.



In applications where it is necessary to use a longer than usual bearing, we sometimes recommend the use of two short bearings with the intervening space to serve as an oil reservoir.

The ideal bearing application is one in which it is possible to achieve a state of uid friction with the journal and the earing completely separated. The only riction present then is in the shearing ction of the layers of oil. Obviously such n application would only be possible here there are high speeds and light loads. But as all bearing applications are not deal, the designer must have ways and eans to come as close as possible to ideal ubricating action.

Obviously, the first step is to assemble ll operating facts. Then the method of istributing the lubricant and the type of ubrication to be used can be decided. Fundamentally, there are four primary methods f distributing the lubricant when it is oil —i.e., force feed . . . splash . . . bath . . . and ing, chain or collar oiling. In selecting the ethod to use, the most important factor o bear in mind is reliability.

Force feed is sometimes referred to as irculating lubrication. It includes all pplications wherein a continuous flow of il is maintained throughout all bearing pplications. In such systems the viscosity of the lubricant is an important feature. It is also necessary to provide some method of purifying the lubricant for repeated use. Other considerations include speed, which should be high enough to build an oil film; dissipation of heat; prevention of leakage and oil oxidation. In some cases it is advisable to provide an oil cooling system to maintain the proper operating temperature of the lubricant.

The splash system involves the use of a completely enclosed crankcase, usually a cooling system and a heavy oil. As lubrication is effected by dipping, this system must provide an indicator so that the proper oil level is always maintained.

In the bath system the operating parts are usually completely submerged in the lubricant. In this method practically the same factors are involved as in the splash method.

Ring, chain or collar oiling involves a system whereby the lubricant is carried from the reservoir to the bearing by a ring or collar that rotates with the shaft to an opening in the top of the bearing. In this system particular attention must be paid to the type of oil grooving of the bearing so that sufficient oil is carried into every part of the loaded bearing area.

Hand oiling can be utilized in some applications although it is usually best to provide an oil cup or a combination of cup and wick.

Up to this point methods of supplying oil lubrication have been outlined. However, in many applications, use must be made of grease due to the nature of the operating conditions. Grease is ordinarily used for rough machinery where usage is severe and clearances are not consistent, and in slow moving equipment since the laws of hydrodynamic action are ineffective.

It is recommended that greases be supplied by some pressure system or pressure guns, since adjustable grease cups give positive action.

In conjunction with lubricating systems consideration must also be given to prevent end or side leakage. This condition in bearings is undesirable because it reduces the load a bearing may safely carry and results in extensive oil waste which creates problems of cleanliness both on the machine and goods in process.

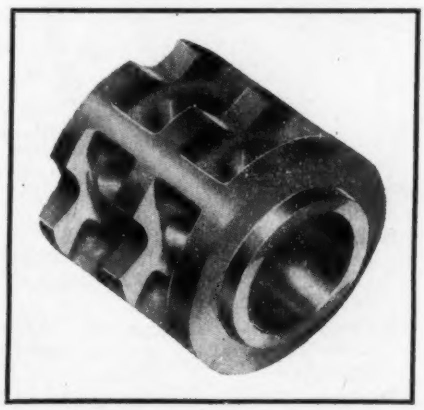
In order to prevent this condition use should be made of proper oil seals which, in addition to conserving oil, keep dirt from entering the machinery.

In all applications in which lubrication is required it is desirable that repeated use be made of the lubricant for reasons of economy. However, it must be remembered that oil is certainly to become contaminated while it is being used and this contamination definitely reduces the effectiveness and efficiency of the lubricant, resulting in injury to bearing surfaces.

Air, in the presence of hot oil, results in oxidation and the formation of sludge. These sludges are often acid in character and are injurious to the bearing linings. In many applications water is prevalent and in mixing with the lubricant tends to dilute the lubricant and make it ineffective as a load carrying medium. In addition, high temperatures are extremely destructive to oils and cause vaporization of the lighter constituent and the formation of carbon. In order to assure clean, suitable oil, two methods are generally used, that of filtering or separation by gravity.

Obviously some methods of lubrication are more expensive than others. There are many ways of reducing costs in designing machinery but the selection of an inferior or inadequate system of lubrication is not one of them. The most expensive bearing in the world is the one that fails. The easiest way to be certain of getting the greatest value and performance out of your bearing applications is to consult with Johnson Bronze. Our engineers are fully competent to give the proper advice and assistance on all your bearing problems. They will work with you without obligation.

In some bearing applications it is often possible and practical to provide recesses on the outside diameter of the bearing which serve as oil reservoirs.



This bearing data sheet is but one of a series. You can get the complete set by writing to—

Johnson Bronze

SLEEVE BEARING HEADQUARTERS
525 S. MILL ST. • NEW CASTLE, PENNA.

NEW PARTS AND MATERIALS

Plastic Pipe Fitting 4

Carlon Products Corp., Cleveland, O.

Form: Standard screw, insert and slip sleeve types; coupling, elbow, tee, adapters

Size: ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 4, and 6-in. pipe

Service: For Carlon plastic pipe, all fluids and gases

Properties: Corrosion resistant, nontoxic, lightweight, insulating

Application: For joining sections of piping systems for low pressures, food processing equipment, and underground, underwater or insulator conduit.

For more data circle MD 4, Page 187

Small Motor 5

Cyclohm Motor Corp., Div. Howard Industries Inc. 1215 *State St., Racine, Wis.*

Style: Model 2900, normal induction, foot-mounted

Size: 1/20, 1/30 and 1/40-hp (4 pole); 1/15, 1/25 and 1/30-hp (2 pole); frames 2922, 2918 and 2914 respectively

Service: 1650-1700 rpm (4 pole) 3400-3500 rpm (2 pole); single-phase a-c

Design: Dynamically balanced rotors; die cast motor frames; permanently lubricated ball or porous bronze sleeve bearings; mounting pads cast on frame, stamped steel base if desired; capacitors normally supplied for remote mounting but can be mounted directly on motor

Application: For driving laboratory equipment, vending machines, tape pulling mechanisms, sound cameras, blowers, etc.

For more data circle MD 5, Page 187

Stainless Steel Hose 6

Allied Metal Hose Co., 37-46 *Ninth St., Long Island City* 1, *N. Y.*

Style: Helically corrugated, flexible; type SN-O normal pitch and SC-O close pitch

Size: Gauge of metal for ¼, ⅜ and ½-in. ID 0.015-in., ¾-in. 0.020-in., and 1¼ in. 0.025-in., 1½-in. 0.028-in., 2 in. 0.031-in., 2½, 3 and 4 in. 0.035-in.; lengths 6 to 7 ft (close pitch), 12 to 14 ft (normal pitch)

Service: Air, steam, gas, and corrosive fluids; test pressures to 5000 psi; temperatures to 2100 F

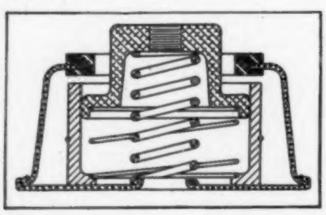
Design: Normal pitch has free flexing from 10 in. (¼ in.) to 41 in. (4-in.) close pitch, 5 in. (¼-in.) to 33 in. (4-in.); stainless steels 304, 316, 347, 310 and Carpenter 20; nonbraided for moderate pressures, braided for high

Application: For flexible connection between movable machine parts or misaligned parts; absorbing slight expansion or contraction, isolating vibration and noise transmitted through rigid piping; air conditioning and refrigeration.

For more data circle MD 6, Page 187

Vibration Mount 7

Lord Mfg. Co., Erie, Pa.



Style: Spring-loaded, friction-damped

Size: Free height 1.53-in.; diameter, 2 in. tapering to 2⅛ in. at base; mount, 2.375 in. sq.

Service: Load ranges—3.0 to 6.5 (J-9797-3), 4.5 to 18.5 (J-4797-2), 4.5 to 8.5 (J-4797-1), with 0.150-in. spacer above ranges increased to 15.5, 29.0 and 20.0 respectively; operational temperatures −80 to 250 F; meet requirements of spec AN-E-19.

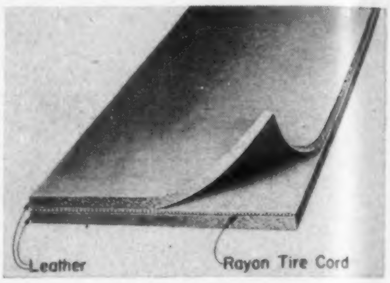
Design: Ratio of radial to axial stiffness varies from 0.32 to 0.90 depending upon applied axial load, increasing as load increases. One piece supporting member tapped for ¼-20 screw, resilient snubbing shoulder, horizontal damping control spring, nonlinear type load supporting spring, self-compensating type molded friction damper, vertical damping control spring; four hole mounting on 1.943-in. centers

Application: For isolating vibrations from base-mounted industrial and aircraft equipment.

For more data circle MD 7, Page 187

Flat Belt 8

Chas. H. Schieren Co., 30 *Ferry St., New York* 7, *N. Y.*



Form: Flat, endless, single, double and triple ply

Size: Widths, ½ to 3-in (¼-in increments) and 3½, 4, 4½, 5, 5½, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 22, 24 in; lengths to spec.

Service: High-speed high-load, power transmission

Design: Two layers of leather with cemented-in rayon tire cords

Application: For machine drives having high-speeds, overloads and no belt take-up such as on textile strippers, mule spinning frames, winders, cone drives, etc.

For more data circle MD 8, Page 187

Mechanical Governor 9

Hoof Products Co., 6543 *S. Laramie, Chicago* 38, *Ill.*

Style: Spring-type centrifugal, enclosed

Size: Mounts to carburetor SAE flange sizes 1, 1¼, 1½, 1¾, 2 in.

Service: Internal combustion engines; updraft or downdraft carburetors; 3000 rpm max

Design: Belt driven from crankshaft, generator, fan, or water pump; ball, roller and needle bearings; thrust surfaces hardened and ground; lightweight throttle actuating lever protects against surging; cast iron housing; all shafts sealed; daily lubrication unnecessary; drive ratio crankshaft pulley to governor pulley 1.25 to 1; close regulation regardless of load conditions

Application: For variable-speed governing of all types of industrial engines.

For more data circle MD 9, Page 187

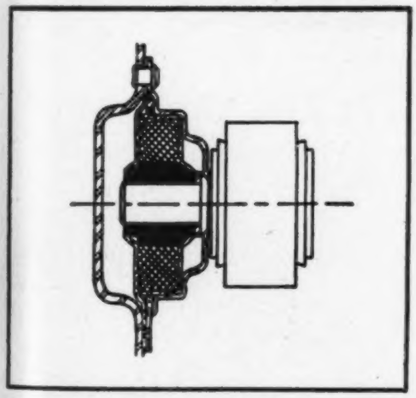
Powder Metallurgy Parts Result in Quiet Operation

Manufacturers of household appliances, business machines and factory equipment have long recognized the importance of quiet operation as a selling tool. Product designers have found economical ways of obtaining this desirable feature through increased use of bearings, gears, cams and other parts produced by powder metallurgy.

These bearings and parts, manufactured under the trade names of "COMPO" (porous bronze) and "POWDIRON" (sintered iron) assure extremely quiet operation because of (1) their accurate dimensions; (2) their method of lubrication.

Accurate Dimensions

"COMPO" and "POWDIRON" bearings and parts are die-formed to their final dimensions within extremely close tolerances. Hence the play of shafts in bearings can be kept to a minimum; gear, cams and similar parts mesh closely and quietly. These advantages are obtained without any need for expensive machining operations to give the required tolerances.



In this application of a self-aligning "COMPO" bearing in an electric fan, accurate dimensioning permits extremely close running clearances, essential for quiet operation.

Method of Lubrication

The lubrication principle used in "COMPO" and "POWDIRON" eliminates any noise-producing metal-to-metal contact between moving parts. When the machine is at rest, oil is stored uniformly throughout the capillary structure of the bearing or part. When the machine starts, oil is instantly fed to the surface from the microscopic pores, thus maintaining a constant oil film.

Recommendations on "COMPO" and "POWDIRON" bearings and parts for specific applications may be obtained from the manufacturer, Bound Brook Oil-Less Bearing Company, Bound Brook, N. J.

Advertisement

"Let's keep this just as quiet as we can!"

EXTREME QUIETNESS is one of the 6* outstanding advantages of "COMPO"® and "POWDIRON"® BEARINGS AND PARTS

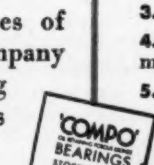
Constantly maintained oil film ends noisy metal-to-metal contact. Accurate dimensioning keeps parts working together smoothly and silently. These are the "let's keep it quiet" features of "COMPO" and "POWDIRON" bearings and parts—put them to work in *your* product!

For the latest line-up of stock sizes of "COMPO" bearings, write on your company letterhead. Consult our Engineering Department on special requirements for bearings or parts.

***THE 6 OUTSTANDING ADVANTAGES OF "COMPO" and "POWDIRON" are:**

1. Extreme quietness
2. Efficient self-lubrication
3. Low installation cost
4. Low operating and maintenance cost
5. High load capacity at high speeds
6. Low unit cost

Send for this *FREE* Booklet



BOUND BROOK

OIL-LESS BEARING COMPANY

BOUND BROOK, N. J. • BOUND BROOK 9-0441

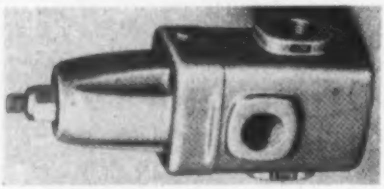
ESTABLISHED 1883

"COMPO" • "POWDIRON" • "BOUND BROOK"

NEW PARTS AND MATERIALS

Hydraulic Valve 10

Rivett Lathe and Grinder Inc. Brighton 35, Boston, Mass.



Style: Model 8826, balanced piston unloader

Size: ¼ to 1½-in. pipe port

Service: Hydraulic fluids; two pressure ranges, 50 to 150 psi and 500 to 1500 psi

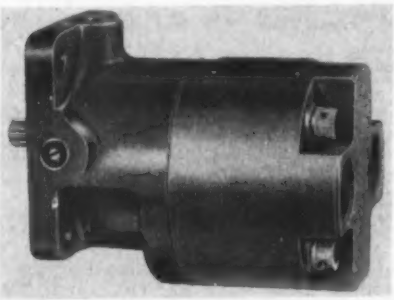
Design: Adjustable from minimum to maximum in both ranges; operated by pilot pressure from part of circuit, free flow continuous as long as pilot pressure is higher than valve setting

Application: For unloading one part of oil hydraulic circuits at no back pressure to tank; specifically for use in controlling flow in combination high and low pressure circuits

For more data circle MD 10, Page 187

Rotary Air Motor 11

Romec Div., Lear Inc., Elyria, Ohio



Style: Model RD-7440A; rotary gear type; flange mounted

Size: Approximate width 2-53/64, height 2-7/16, length 3-11/16-in.; total weight 1.5 lb; two ports tapped 9/16-18 NF3 thread per AND 10050

Service: Displacement, 0.310 cu in.; air pressure 1500 psi., operates in either direction of rotation; torque at 1000 psi and zero rpm 44 in.-lb

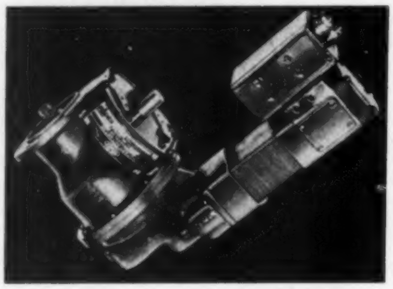
Design: Speed varied by control of air feed to motor; splined drive shaft, 12 teeth, 40/80 pitch, 30-degree pa; needle bearings. Lubricated with low-temperature aircraft grease, spec AN-G-25

Application: For emergency actuation of aircraft units such as pilot's canopy; suitable for general machine actuation requirements where rotary motion is desired and high-pressure air is available.

For more data circle MD 11, Page 187

Rotary Actuator 12

Electrical Engineering & Mfg. Corp., Los Angeles, Calif.



Style: Electromechanical, rotary

Size: 1¼ hp

Service: 9000 rpm continuous; duty cycle at full load—one second on clockwise, one second off, one second counterclockwise; case temperature 110 C at rated cycle; conforms to ANM-40 spec.

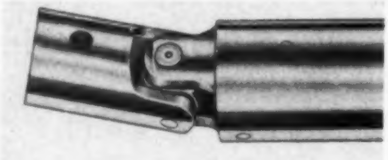
Design: Motor wound with silicone insulation; equipped with magnetic cutch and brake, radio noise filter, manual overdrive and torque limiting device

Application: For special drives such as automatic pilot control.

For more data circle MD 12, Page 187

Universal Joint 13

Curtis Universal Joint Co. Inc., Springfield 7, Mass.



Style: Block and pin type, bored or solid

Size: Fourteen sizes; hub OD ⅜ through 4 in.; total length 1¾ through 10⅝; bore 3/16 through 2; hub length 11/16 through 2 in.; weights 0.05 through 31.3 lb (solid) 0.04 through 25.8 lb (bored)

Service: Heavy-duty; speeds to 4000 rpm, max; static torque ratings 140 through 131,000 in.-lb; angles to 30 degrees, will perform at 37 degrees but not recommended

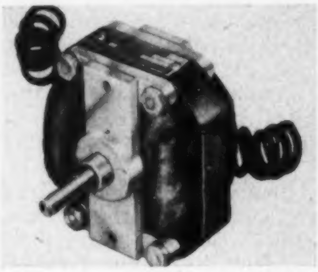
Design: All parts heat treated; forks—alloy steel ground; hubs—broached or bored for square, round, keyed or splined shafts; pin holes broached and bored; pins—hardened and centerless ground; lubrication—oil hole in large pin in sizes to 1-in. hub, internal grooves in larger sizes; lock ring for quick disassembly

Application: Heavy-duty torque drives.

For more data circle MD 13, Page 187

Small Skeleton Motor 14

Electric Motor Corp. Div. Howard Industries Inc., Racine, Wis.



Style: Model 800D, four-pole shaded, skeleton type

Size: 1/200 to 1/80 hp

Service: Speed range 60 cycle a-c, 1600 rpm idle, 1450 rpm full load; 115 v a-c special available

Design: Porous bronze bearings with oil reservoir or grease sealed ball bearings; gear reducers and cooling fans available

Application: For built-in drives for dictating machines, milk coolers, laboratory apparatus, or heating and ventilating equipment, etc.

For more data circle MD 14, Page 187

Pillow Block 15

Boston Gear Works, Quincy, Mass.

Style: Self-aligning, ball bearing, types BNS, BNM, and BNL, foot mount; types BNFS, BNFM and BNFL, flange mount

Size: Shaft diameters ½, ⅝ and ¾-in. (BNS) ⅞ and 1 (BNM) 1-3/16 and 1¼ (BNL)

Service: Radial load ratings (thrust loads to 50 per cent), 300 lb at 3000 rpm to 1150 lb at 50 rpm (BNS), 340 lb, 3000 rpm to 1300 lb, 50 rpm (BNM) and 650 lb, 3000 rpm to 2550 lb, 50 rpm (BNL); rated at normal steady operating conditions, temperatures between 0 to 150F

Design: Spherically ground chrome alloy ball bearings; high-grade cast iron housing; safety-vent seal for automatic regulation of lubricant; bearing slip fitted on shaft; inner race setscrew locked to shaft

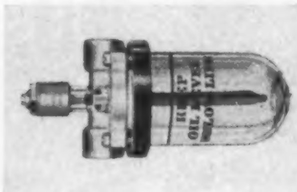
Application: For antifriction mounting of machine drive shafts requiring self-alignment

For more data circle MD 15, Page 187

NEW PARTS AND MATERIALS

Centralized Lubricator 16

C. A. Norgren Co., 222 Santa Fe Drive, Denver 9, Colo.



Style: Air-lubricant spray type

Size: ¼ and ⅜-in pipe; both sizes with 1/3 or ½-pint bowl sizes

Service: Atomizing standard lubricating oils; 1 cfm at 10 psi to 14 cfm at 80 psi; safe operating pressure, 125 psi max

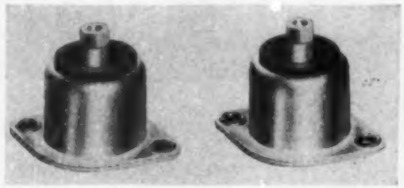
Design: Sight feed and visible oil supply; lubricates only when air flows; drops atomized to two-micron particles enter supply line, larger remain in oil bowl; oil can be metered to as little as one drop per 20 minutes

Application: For lubrication of high-speed machine components such as grinding spindles, gear trains, air meters, etc.

For more data circle MD 16, Page 187

Vibration Mount 18

Barry Corp., 722 Pleasant St., Watertown 72, Mass.



Style: Air-damped, flanged

Size: 1-in. diameter, 1-1/32 in. high max rated load; weight ¼-oz

Service: Load ratings 0.1 to 3.0 lb; operating temperatures −65 to +170F

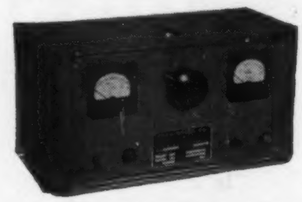
Design: Nonlinear steel springs for substantially constant resonant frequency throughout two-to-one load range; aluminum shells, and rubber air chambers and snubbers; attachment stud with 6-32 female thread ¼-in. deep; two mounting holes on 1-9/64-in. centers or four mounting holes on 1-in. centers

Application: For isolating miniature aircraft and industrial equipment from vibration and shock.

For more data circle MD 18, Page 187

D-C Power Supply 20

Opad-Green Co., 71 Warren St., New York 7, N. Y.



Style: Models GPA810, GPA1210 and GPA2810 (variable voltage); P810, P1210 and P2810 (fixed)

Size: 8 x 16¾ x 8½ in. high

Service: Ranges 0-8, 0-12 and 0-28 v d-c 10 amps respectively (ratings based on continuous duty, normal convection cooling, resistive and inductive loads, max 35 C ambient); a-c input, 115 v 60 cycle single phase

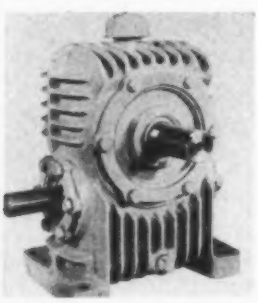
Design: A variable and fixed-ratio transformer on adjustable units; full wave selenium rectifiers; d-c voltage and current read on two 3-in meters

Application: For providing low-voltage d-c power to industrial and laboratory electrical circuits.

For more data circle MD 20, Page 187

Speed Reducer 17

Cone-Drive Gears, Div., Michigan Tool Co., Detroit 12, Mich.



Style: Right-angle models SU (pinion under gear shaft) SO (pinion over) SV (gearshaft vertical); right or left hand shaft

Size: No. 7300; 3-in. center distances, SU—14-in. high including breather, 10⅞ in. wide including shaft, 10 in. deep including shaft, weight 83 lb; SO—12½ x 11 5/16 x 9 3/16 in., 73 lb; SV—10 5/16 x 11 3/16 x 11 5/16-in., 74 lb; gear shaft 2 5/16-in. extension 1½ in. diameter; pinion shaft 2½-in. extension 1⅛ in. diameter

Service: Ratios 5, 10, 15, 20, 25, 30, 40, 50, and 60:1; hp ratings for respective ratios at 1750 rpm 9.04, 6.11, 4.39, 3.40, 2.77, 2.32, 1.75, 1.40, and 1.13

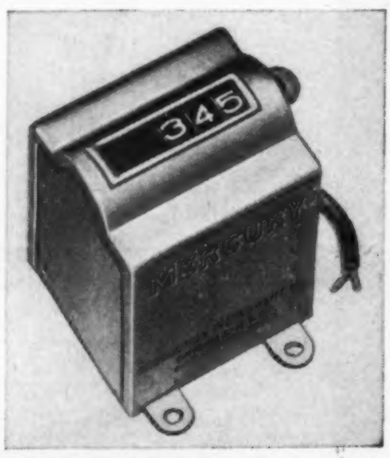
Design: High carbon alloy steel pinion; chill cast copper-tin bronze double-enveloping gearing; ball and roller bearings; oil breather; splash lubrication

Application: For speed reduction of right-angle machine drives.

For more data circle MD 17, Page 187

Electric Counter 19

Production Instrument Co., 702-08 W. Jackson Blvd., Chicago 6, Ill.



Designation: Mercury

Style: Roll-back reset, 1, 2, 3, or 4 digit

Size: 2-13/32 in. high, 1-23/32 in. wide and 1-9/16 in. deep

Service: Counts to 1000; 6, 12, 24, 48, or 115 v d-c or 60 cycle a-c

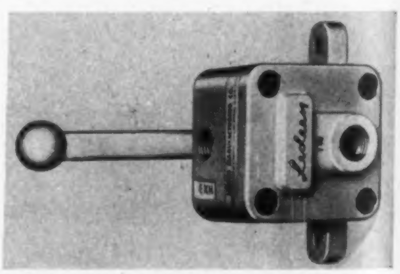
Design: Reset by turning knob; actuated by switch, relay or photoelectric unit; installed any distance from source of count

Application: For electrically actuated counting in such repetitive actions as materials conveying, parts feeding, etc.

For more data circle MD 19, Page 187

Fluid Control Valve 21

Ledeen Mfg. Co., 1602 So. San Pedro St., Los Angeles 15, Calif.



Style: Rotating disk; 4-way; hand, foot, and pilot operated

Size: Pipe taps ⅛, ¼, ⅜, ½, ¾, or 1 in.

Service: Air, oil or water to 250 psi

Design: Hand operated — neutral position, lever turns 45 degrees each way from neutral — foot-operated — single pedal without neutral, 30-degree movement, spring return; double pedal with neutral 15-degree movement each way, spring return; double pedal without neutral, pedal return — pilot operated—remote pilot valve, direct solenoid or hand operated by means of poppet controlled attached valve piston, no neutral, pilot connected direct to poppet ports

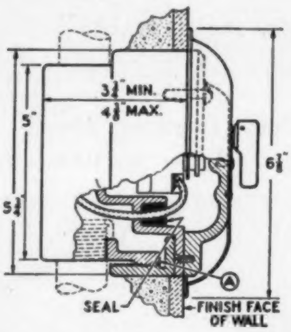
Application: For control in machine pneumatic or hydraulic systems.

For more data circle MD 21, Page 187

NEW PARTS

Heavy-Duty Switch 22

Russell & Stoll Co., Inc. 125 Barclay St., New York 7, N. Y.

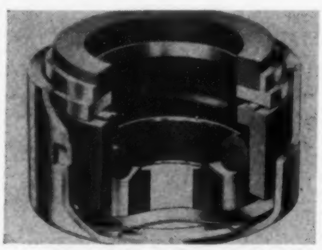


Style: Tumbler type, explosion-proof; 1 or 2 poles, 3 or 4 way
Size: Face diameter 6⅞ in., body diameter 5¾ in.; 4-way outlets
Service: UL Class I Groups C and D; 125 v or 250 v, 20 amp (1 and 2 pole, 3-way) 125 v 10 amp, 250 v 5 amp (4-way)
Design: Adjustable flush face mounting 3¾ in. min wall depth to 4⅜ max; pigtail leads sealed in
Application: Electric control circuits.

For more data circle MD 22, Page 187

Mechanical Shaft Seal 23

Sealol Corp., 45 Willard Ave., Providence 5, R. I.



Style: Model FCB (external pressure) and GCB (internal pressure) with or without lock ring
Size: Eleven sizes; shafts 0.375 to 1.625-in.; installation dimensions (diameter and length) 1.051 x 0.875 in. to 2.673 x 1.188 in.
Service: Rotating shaft; sealing against atmospheric contamination and from water, oil, kerosene, gasoline, and other low-pressure fluids
Design: Self-contained; clamp model tightened to shaft by set screws; relative movement at lapped faced only; noncorrosive construction, materials to suit requirements; synthetic gasket; balanced pressure principle minimizes seal face pressures, frictional drag, torque
Application: For sealing rotating shafts on pumps, motors, gear boxes, compressors, washing machines, etc.

For more data circle MD 23, Page 187

ENGINEERING DEPARTMENT

EQUIPMENT

For additional information on these new developments, see Page 187

Slide Rule 24

Trane Co., Educational Div., La Crosse, Wis.

Style: Circular

Service: Design calculations in fan systems

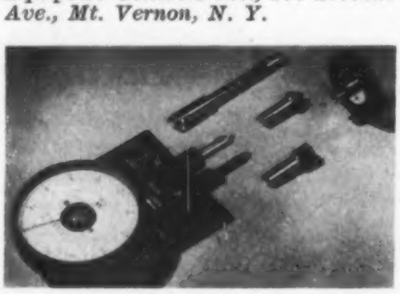
Design: Four scales at different radii from pivot; all scales colored differently for easy reading

Application: For determining friction loss per 100 ft of duct, diameter of round duct and dimensions of rectangular duct suitable for any known cfm air load.

For more data circle MD 24, Page 187

Hand Tachometer 25

Equipoise Controls Inc., 100 *Stevens Ave., Mt. Vernon, N. Y.*



Style: Model ATH 10, dual range

Size: Dial diameter 3 in., combined length spindle housing and spindles 1-13/16 in.; case 2⅛ in. wide 3¾ in. long and 1-5/16 in. deep

Service: Speed ranges, 0-1000 rpm and 0-5000 rpm

Design: Alnico drive; guaranteed accuracy 0.5 to 1% over entire range; knurled knob for range selection and pushbutton on either side of instrument for releasing or holding pointer at indicated machine speed; 0.40 oz-in. torque on lowest range; female and male centers, 3½-in. extension; 6-in. circumference surface measuring disk

Application: For measuring machine speeds.

For more data circle MD 25, Page 187

Tracing Vellum 26

K L H Corp., Port Chester, N. Y.

Designation: Perma Trace

Form: Transparent sheet, rag synthetic resin treated

Service: Pencil or ink

Properties: Unaffected by extended exposure to light, heat or atmosphere; water repellent; nonghosting erasures

Applicaton: For pencil or ink engineering drawings.

For more data circle MD 26, Page 187

Carrier Amplifier 27

Consolidated Engineering Corp., 620 *N. Lake Ave., Pasadena* 4, *Calif.*

Style: Type 1-118, measuring and recording

Size: 9 × 17 × 12 inches

Service: Oscillator develops 5 v rms 3 kc carrier for exciting transducers; frequency range 0 (static) to 500 cps, recorded-trace rise time of less than 500 microseconds; system sensitivity adjustable so that input signals less than 1.875 millvolts to over 600 millvolts give full scale output; operate on 105 to 125 v source, 50, 60, or 400 cycles

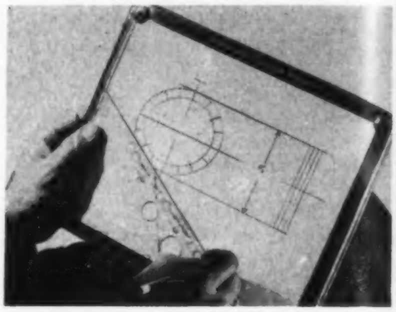
Design: Single cabinet; system includes 3-kilocycle carrier oscillator, four carrier amplifiers, regulated power supply and controls

Application: For use with strain gages or transducers employed to measure stress, strain.

For more data circle MD 27, Page 187

Portable Drawing Board 28

A. Partrick Co., Westwood, N. J.



Style: One piece molded styrene plastic, transparent

Size: 9¾ x 12¼-in.; 8 oz

Service: Holds 8½ x 11-in. paper

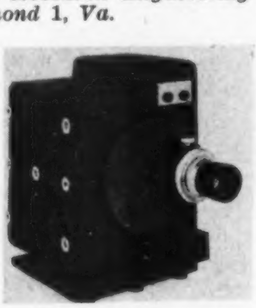
Design: Four corner clamps hold paper; two metal retractable straight edges serve as T-square; triangle storage on underside.

Application: For drawing or sketching design ideas in office or field.

For more data circle MD 28, Page 187

Recording Camera 29

Flight Research Engineering Corp., Richmond 1, *Va.*



Style: Model IV synchronous

Size: 8-7/16 x 5-11/16 x 5½ in.

Service: 35 mm film; single-frame or continuous exposures; change gears for 5, 10, and 20 frames per second (exposure time 1/50, 1/100 and 1/200 respectively) or 4, 8, 16 and 32 fps; ambient air temperatures from −55 to 75 C

Design: 100-ft daylight loading spools; synchronous control mechanism maintains all shutters of a parallel camera gang within max divergence of 5 degrees on 1/700-second at 10 fps; silver drum capstan clutch with special actuator; clutch circuit can be linked with single-channel radio

Application: For simultaneous motion-picture or single-frame photography and data recording of one or more subjects.

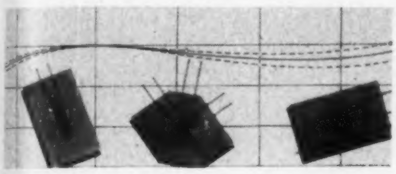
For more data circle MD 29, Page 187

ENGINEERING DEPARTMENT

EQUIPMENT

Strain Gage 30

Baldwin-Lima-Hamilton Corp. Philadelphia 42, Pa.



Size: Four gage lengths in single element ¼, ⅜, 13/16, and ⅞-in.

Service: Stress analysis; Dural or steel; two temperature ranges 50 to 300 F and −50 to 300 F

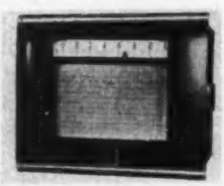
Design: Temperature-compensated; single element gages standard, double element and rosettes special order; similar to bakelite gages with cupro-nickel wire, applied by same methods

Application: For use in measuring surface strains which may also be related to other physical quantities as pressures, forces, etc.

For more data circle MD 30, Page 187

Electronic Recorder 31

Bristol Co., Waterbury 20, Conn.



Style: Series 500 strip-chart, 1 to 16 records

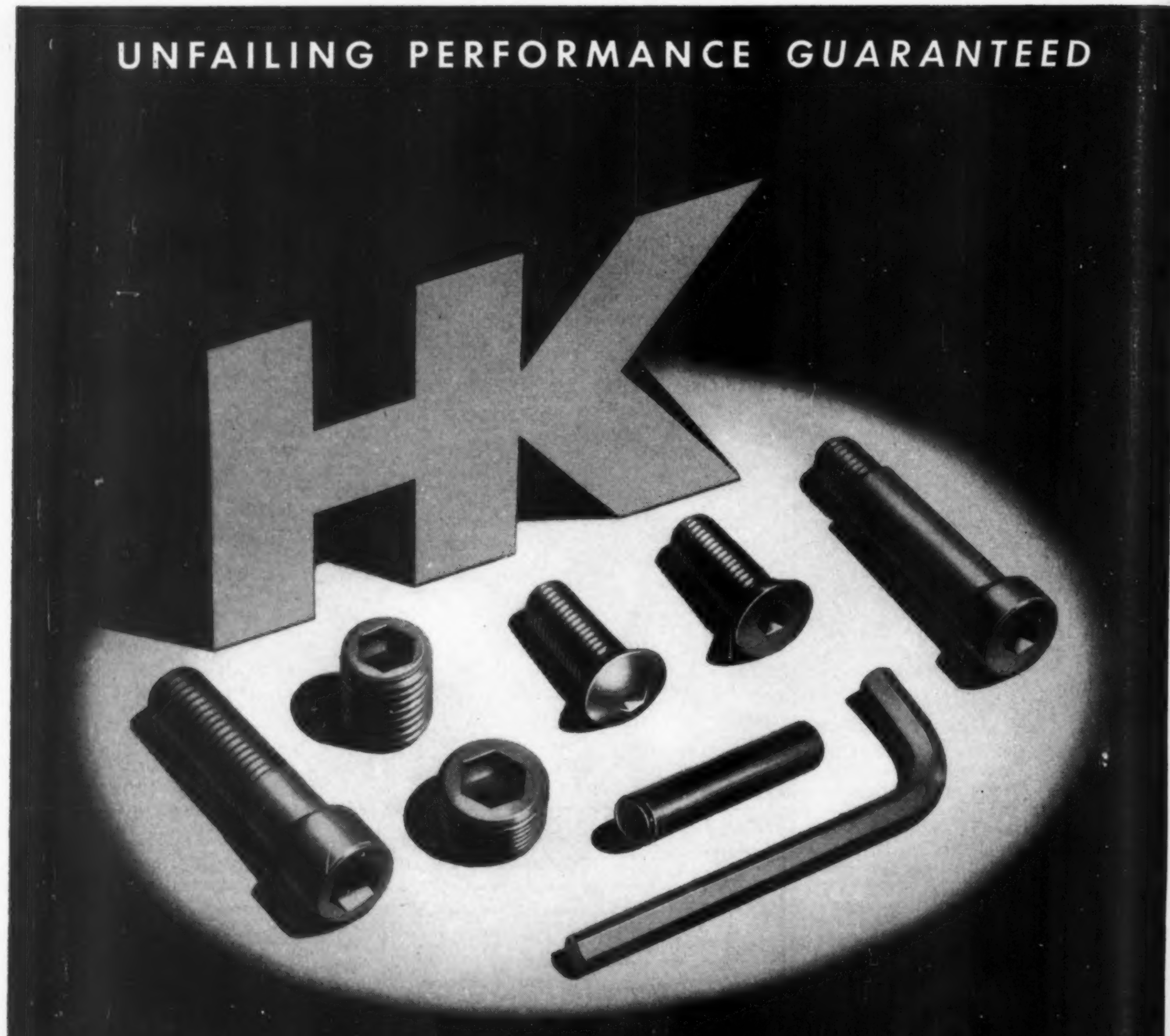
Size: Chart, 12¼-in. wide with 11-in. calibrated width; scale 1¼-in. high.

Service: Measurements in terms of resistance; full scale thermometer ranges from 0F to 400F, other measurements 0 to 30 to 0 to 10,000; chart speeds 1, 2, 3, 6, 9, 12, 18 and 24 in. per hour or ½, 1, 1½, 3, 30, 60, and 120 in. per minute; 120 ft of chart per roll; 115 v 60 cycle power; high-speed, self-balancing a-c bridge

Design: Synchronous electric motor drive, electronic amplifier, constantan dual slide wire with min of 2000 turns, Wheatstone circuit; flush or surface mounted; gass pen with platinum-iridium tip; charts speeds changed with change gears

Application: For measurement or automatic control of temperature, resistance, conductivity, strain.

For more data circle MD 31, Page 187


UNFAILING PERFORMANCE GUARANTEED
HK
HOLO-KROME
Completely Cold Forged
SOCKET SCREW PRODUCTS
Available through Authorized Holo-Krome Distributors.
505
THE HOLO-KROME SCREW CORP., HARTFORD 10, CONN., U.S.A.

HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

75. Ornamental Grilles

Harrington & King Perforating Co.—48-page illustrated catalog No. 33 presents large selection of ornamental grille patterns. Both classic and modern designs are pictured together with dimensions. Special grilles, fixed and movable louvers, special panels and enclosures are shown.

76. Electrical Instruments

Reliance Instrument Co.—8-page illustrated bulletin C-50 covers various types of electrical instruments including switchboard, panel, portable and combination types as well as ammeters, voltmeters and wattmeters for special applications.

77. Welding Electrodes

Sylvania Electric Products Inc., Tungsten & Chemical Div.—4-page illustrated bulletin No. 100 describes sizes, finishes and recommended types of pure tungsten electrodes for alternating and direct current inert-gas electric arc and atomic hydrogen welding.

78. Rust Preventives

Nox-Rust Chemical Corp.—4-page illustrated bulletin "Transparent Rust Preventives" gives recommended uses, film and liquid characteristics, application methods and other data on two new transparent flexible coatings which afford protection of metal parts in storage or shipment.

79. Adhesives & Sealers

Minnesota Mining & Mfg. Co.—32-page illustrated booklet "3M Adhesives, Coatings and Sealers" tabulates properties of over 100 of these industrial materials. Also included is section covering 15 Coro-Gard protective coating systems and parts devoted to materials for shipbuilding, construction and oil industries.

80. Self-Lubricating Packings

Greene, Tweed & Co.—20-page illustrated catalog PC-101 covers Palmetto self-lubricating molded and sheet packings, gaskets and Pisto-Ring packing for liquid pistons on inside-packed piston pumps. Data are included on application, structure, performance and selection.

81. Plastics Surfacing

General Electric Co.—16-page illustrated bulletin CDL-18 presents line of Textolite plastics surfacing colors and patterns for commercial and industrial applications. Use of materials, construction details and properties are covered.

82. Rotary Multipole Switches

Electro Switch Corp.—8-page illustrated catalog 1950-JR is guide to rotary multipole tap and transfer switches that conform to Navy and Underwriters' Laboratories requirements. Sectional views, application data, contact possibilities and other information on 4, 8 and 16-position switches are included.

83. Automatic Molding

F. J. Stokes Machine Co.—24-page illustrated manual "Fully Automatic Molding of Thermosetting Plastics" explains origin, growth, advantages and use of this production method. Technique, costs, efficiency, advantages and applications of automatic molding are discussed. Case studies deal with typical parts produced automatically.

84. Welding Guns

Progressive Welder Sales Co.—4-page illustrated pictorial No. 5066 is descriptive of Magna-Lyte portable welding guns made from Magna-Lyte castings. Light in weight, metal has high strength and wear-resisting properties, good oxidation and corrosion resistance, and high thermal and electrical conductivity.

85. Electric Motors

Ideal Electric & Mfg. Co.—12-page illustrated booklet "Ideal Motors and Liquid Gold" describes how low-speed synchronous motors ranging from 100 to 800 hp drive compressors which are used to supply refrigeration to concentrators, votators in packing room and for maintaining low temperatures required in orange juice concentrating.

86. Close Tolerance Tubing

Tube Reducing Corp.—8-page illustrated folder R-3 describes compression-forming process for producing close tolerance tubing and lists tolerances, surface finishes, mechanical properties, shapes and sizes. Also shown is how process increases mechanical properties of steel.

87. Adhesives

B. F. Goodrich Co.—8-page illustrated catalog section No. 9160 lists each type adhesive manufactured, materials for which they are specifically recommended and method by which most effective bond is created. Materials covered include Buna N compounds and coated fabrics; neoprene, natural and GRS rubber; and various laminating compounds.

88. Industrial Hose & Fittings

Weatherhead Co.—Illustrated catalog H-1451-A presents revised information on reusable steel hose ends and industrial hose. Couplings in medium, medium-high and high pressure types are covered as are SAE 37 and 45-degree flare adapters.

89. Electric Instruments

Hickok Electrical Instrument Co.—1-page illustrated form 64-65 describes new Lucite-window 3½-in. rectangular semiflush meters which have scale length of 3¼-in. Mounting dimensions are given.

90. Pneumatic Motors

Bellows Co.—24-page illustrated bulletin CL-30 depicts typical uses of air motor which consists of integral air cylinder, directional valve and two speed regulating valves. Manual or electric control is possible. Mounting styles include foot, pivot, flange, nose and combinations. Motor can be employed to actuate feeds, vises, presses and rotary tables.

91. Relays, Motors & Timers

Potter & Brumfield—24-page illustrated catalog No. 100 presents information on shaded-pole motors, relays and timers for electrical and electronic application. Overall mounting dimensions, reference charts and coil data are listed.

92. Tank Heads

Commercial Shearing & Stamping Co.—4-page illustrated bulletin "What's A-Head at Commercial" shows typical U-shaped, hemispherical, obround and segmental heads which are produced in wide range of sizes for all types of tanks.

93. Flexible Ball Joints

Barco Mfg. Co.—16-page illustrated catalog No. 215 lists various types of flexible ball joints designed to provide flexibility in piping. Joints are used to overcome piping misalignment, to guard against vibration and shock and to permit movement of loading or unloading lines. Joints can be obtained in 12 styles and 15 sizes from ¼ to 12 in. and offer seven different service specifications.

94. Pyrometer Accessories

Arklay S. Richards Co.—16-page illustrated catalog No. 5 lists specifications of complete line of pyrometer supplies which includes thermocouples, protection tubes, thermocouple wires, lead wires and insulators. Accessories are available to fit all makes of pyrometers.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below

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95. Fluid Motors

Denison Engineering Co.—8-page illustrated data sheet FM-3 lists operating characteristics and dimensions of three series of fluid motors which can be operated at speeds of 2000 to 3000 rpm and at maximum pressure of 5000 psi.

96. Bronze Electrodes

Ampco Metal, Inc.—24-page illustrated bulletin W-17 is reference and instruction book on welding with Ampco bronze electrodes. Recommended techniques, machining suggestions and charts covering selection, preheating and weldability are included.

97. Flat Belts

Thermoid Co.—8-page illustrated form No. 3678 deals with flat transmission belting. Available belt constructions, typical grades, horsepower capacity, pulley diameters, belt proportions and working formulas are given to aid in selection and application of proper flat belt for individual drive.

98. Air Hose Fittings

Snap-Tite, Inc.—1-page illustrated "Snap-Tite Bulletin" is devoted to information on uses of Snap-Tite hose couplers in industry. This quick-disconnect unit is available with automatic shut-off to prevent loss of air when connection is broken.

99. Variable Speed Control

Reeves Pulley Co.—12-page illustrated bulletin No. G-509 describes three basic units around which infinitely variable speed controls are built. These include transmission, Motodrive and motor pulley. Speed controls are adaptable to new machine designs or can be installed on machines already in service.

100. Inert Arc Welding

Metal & Thermit Corp.—8-page illustrated bulletin form E-142 covers gas-shielded arc welding process using helium or argon. Applications, operating hints and specifications of required equipment are covered.

101. Synchronous Motors

Electric Products Co.—4-page illustrated bulletin No. 44-200 describes various types of low-speed synchronous motors available in 20-hp ratings and larger, 450-rpm speed and below and with bracket, pedestal or engine-type construction for all commercial power supplies.

102. Glass Fiber Ducts

Arrowhead Rubber Co.—16-page illustrated catalog No. 508 describes line of flexible and rigid Fiberglas ducting, hose, sleeves and couplings. Engineering data given includes weights, working temperature ranges, design working pressures and leakage factors. Comparative characteristics of more than 130 types and constructions are shown.

103. Parts Fabrication

Ex-Cell-O Corp.—2-page illustrated bulletin tells how company can produce all types of parts to user's specifications and describes facilities available for machining, heat treating, sub-assembly and inspection from rough stock to finished article.

104. Abrasion Testing Set

Taber Instrument Corp.—8-page illustrated bulletin No. 5003 describes model No. 140 standard abrasion testing set designed to evaluate resistance of surfaces to rubbing abrasion. Its range of application includes tests of painted, lacquered, electroplated and plastic-coated materials as well as textile fabrics.

105. Grinding Wheel Bond

Chicago Wheel & Mfg. Co.—4-page illustrated folder "79E" describes new vitrified bond developed for use in company's grinding and mounted wheels. This abrasive development is reported to afford 5 to 10 per cent increase in grinding and finishing output.

106. Thin Stainless Steel

Armco Steel Corp.—4-page illustrated bulletin is entitled "Paper-Thin Stainless for Light Vital Parts." Typical mechanical properties, available sizes and application data are given on stainless steel from 0.01 to 0.001-in. thick. Described is Armco 17-7 thin-gage strip which has tensile strength comparable to high carbon spring steel.

107. Motor Lubrication

U. S. Electrical Motors, Inc.—4-page illustrated bulletin No. 1579 presents studies in bearing lubrication for electric motors. Comparative amounts of lubrication required in different designs of bearings are shown. Lubriflush principle which affords lubricated-for-life bearings, means for purging of lubricant and renewal of lubricant is explained.

108. Welding Alloys

Eutectic Welding Alloys Corp.—4-page illustrated booklet contains photo-micrographs that show how low temperature welding alloys avoid distortion, stress, warpage and embrittlement in industrial welding practice.

109. Stainless Steels

Carpenter Steel Co. — Slide chart presents technical data and information on workability of stainless steels. Included is standard analysis table of various types together with corresponding AISI type numbers and relative fabricating data for variety of operations. Forms in which each type is produced are listed.

110. Flat Leather Belts

American Leather Belting Association—40-page illustrated "Uni-Pull Drive Manual" enables reader to select, without calculation, proper size of flat leather belt and pulleys to transmit power from given horsepower and speed to machine to be operated at prescribed speed.

111. Disk Thermostats

Stevens Mfg. Co.—2-page illustrated form F-2009 is descriptive of type M bimetal disk thermostats with quick make-and-break operation for use in appliance, electronic, aviation and apparatus applications. Dimensions, operating principle and typical response curves for standard and hermetically-sealed models are covered.

112. Precision Castings

Alloy Precision Castings Co.—8-page illustrated brochure "The Ultimate in Precision Castings" shows step-by-step production of stainless aircraft parts by Mercast precision casting process. Ferrous and nonferrous castings are illustrated, and use of booking dies is discussed.

113. Steel Bar Stock

A. Milne & Co.—4-page illustrated bulletin AM-100 is guide to steel bar stock that is cold drawn in special sections to fit specific purposes. Pre-shaped feature minimizes need for machining operations during production. Typical sections are shown, and indication is given on various analyses in which stock is available.

114. Mechanical Shaft Seals

Garlock Packing Co. — 12-page illustrated form AD-144 describes mechanical seals for rotary shafts. Sealing is effected by positive contact between lapped metal-to-carbon or metal-to-metal mating surfaces. One element rotates with shaft and other is stationary.

115. Magnetic Separator

Eriez Mfg. Co.—2-page illustrated bulletin B-557 describes Extrapower, Ultrapower and Superpower magnetic separators of ATOMagnet line which are constructed for use on wood or metal chutes, hoppers and tables to remove tramp iron from material in process.

116. Cast Tool Steel

Jessop Steel Co.—16-page illustrated bulletin entitled "Jessop Cast-to-Shape Steels" explains how manufacturers who use dies, forming tools, gages, hobs, rolls and other products can improve their service by employing tool steels which are cast to shape. Properties of various tools, stainless and heat-resisting steels are listed, and application and heat treating instructions are included.

117. Torch Welding

Linde Air Products Co.—28-page illustrated booklet F06190 contains data on welding, surfacing and hardening of many commercially-used metals. Chapters are included on fundamentals of the process, description of and instructions for handling torches, and properties of each metal with precautions for welding them.

118. Transformers

Westinghouse Electric Corp.—24-page illustrated bulletin B-4428 explains why dry-type transformers are safe and economical to install and maintain in industrial plants, mines, utilities and other locations. Types covered range from small styles for operation of interoffice communication systems to power centers as large as 10,000 kva.

119. Aircraft Fittings

Parker Appliance Co.—58-page illustrated Aircraft Fittings Catalog 701 tabulates dimensional data for complete size range of AN-specification tube, hose, pipe, universal, bulkhead and swivel fittings. Tube fabrication is covered in special section which depicts tube cutting, flaring and bending tools and accessories.

120. Cleaning Compound

Detrex Corp.—Illustrated folder describes multi-purpose Detrex No. 10 cleaning compound that can be used as medium-duty soak tank cleaner; as electrolytic cleaner for ferrous metal parts; and as water conditioner for all types of water-wash paint spray booths.

M. D. Numbers

1	21	41	61	81	101
2	22	42	62	82	102
3	23	43	63	83	103
4	24	44	64	84	104
5	25	45	65	85	105
6	26	46	66	86	106
7	27	47	67	87	107
8	28	48	68	88	108
9	29	49	69	89	109
10	30	50	70	90	110
11	31	51	71	91	111
12	32	52	72	92	112
13	33	53	73	93	113
14	34	54	74	94	114
15	35	55	75	95	115
16	36	56	76	96	116
17	37	57	77	97	117
18	38	58	78	98	118
19	39	59	79	99	119
20	40	60	80	100	120

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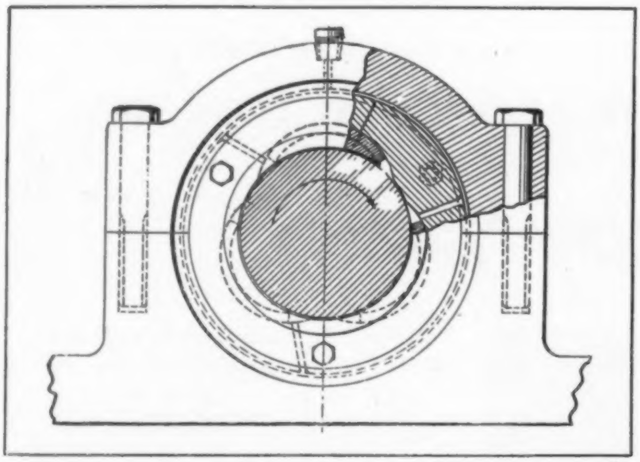
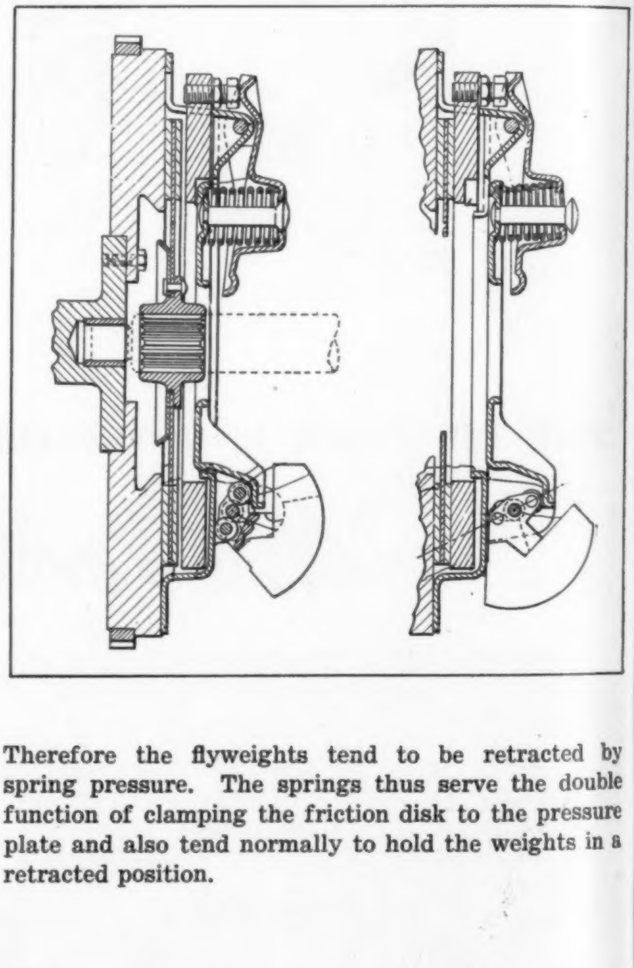
NOTEWORTHY PATENTS

LUBRICATION FILM between bearing and journal surfaces in radial bearings is maintained by floating bearing shoes covered in patent 2,498,011. Backs of the shoes are arc shaped, with the radius of curvature less than the radius of the journal. When the oil film is broken, the increased friction or resistance causes the bearing shoe to be dragged slightly in the direction of shaft rotation, tilting the shoe and allowing a thin film of oil to be entrained in the approach side of the shoe. Build up of the oil film returns the bearing shoes to their concentric positons. Earl H. Sherbondy has assigned the patent to Gridiron Steel Co.

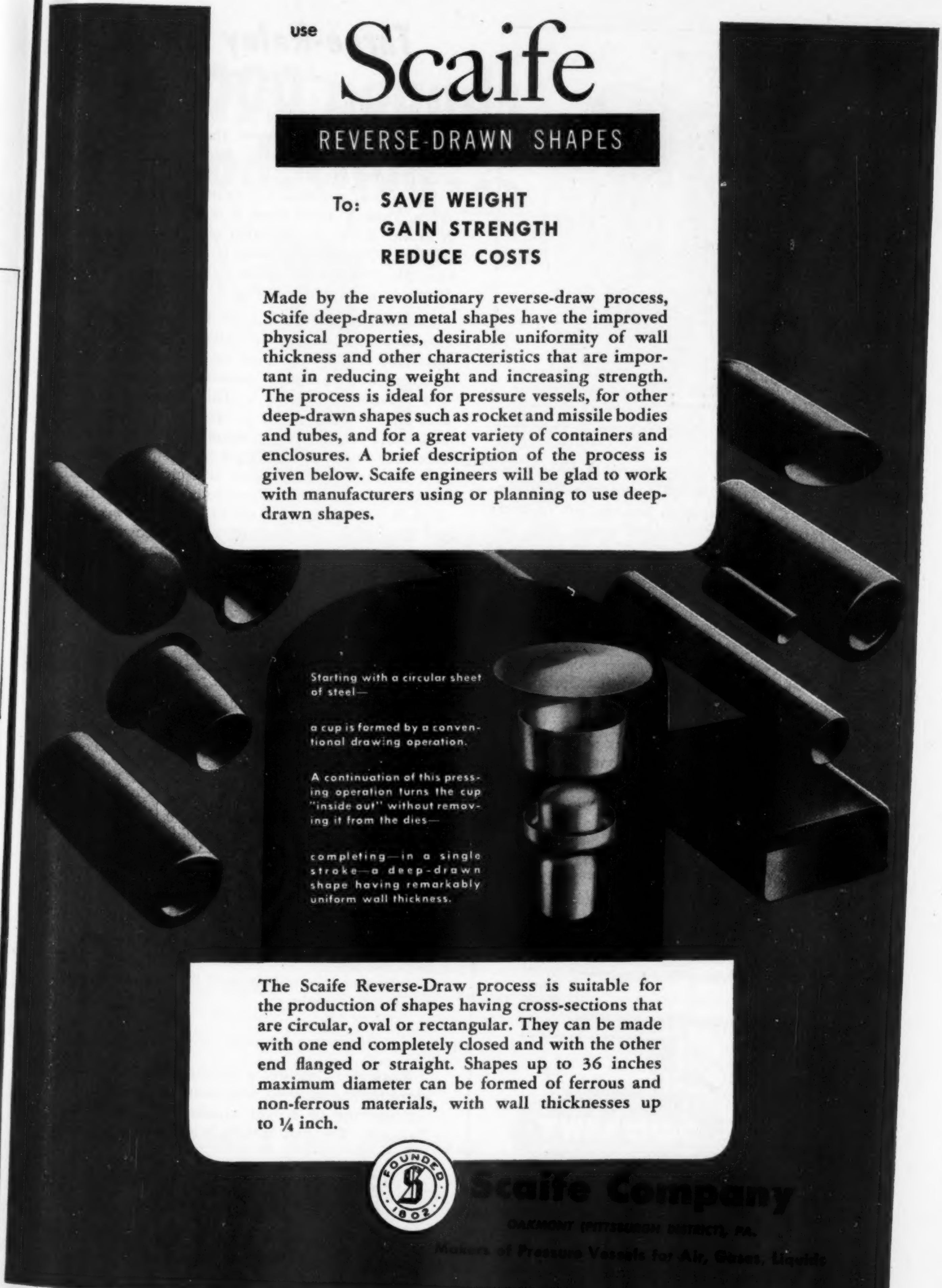


AUTOMATIC ENGAGEMENT of an automotive clutch through pivoted flyweights and a spring loading ring is described in patent 2,513,378, granted to W. Vincent Thelander and assigned to Dana Corp. Leverage between the spring loading ring and the pressure plate is such that, when the flyweights are pivoted outward by centrifugal force, the engaging force is multiplied. The clutch may be easily disengaged by depression of a clutch pedal, even though the engine is running above the engaging speed, since location of the throw-out collar results in a higher mechanical advantage than that provided by the engaging linkage. Rollers on the flyweights, which act on the pressure and back plates to engage the clutch, are so located that even when in the extreme outward position, the rollers do not go over center.



Therefore the flyweights tend to be retracted by spring pressure. The springs thus serve the double function of clamping the friction disk to the pressure plate and also tend normally to hold the weights in a retracted position.

COUNTERBALANCING THE VANES in rotary-vane fluid pumps permits output pressure to be increased or decreased with increasing pump speed, or holds output pressure constant despite speed variation. Pivoted vanes are curved to fit the near side of an eccentric housing and are radially spring loaded outward toward the pump housing. The vanes are provided with counterweights to give a predetermined moment of inertia relative to the moment of the vanes. Where output pressure is designed to increase with increase in pump speed, counterweights are small or are omitted entirely so that centrifugal force of the vanes, plus spring pressure, increases pressure of the vanes on the housing, reducing slip and thus increasing output pressure. Where decreased pressure with increased speed is desired, counterweights are made larger so that their centrifugal effect overcomes that of the vanes plus spring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GAIN STRENGTH
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Made by the revolutionary reverse-draw process, Scaife deep-drawn metal shapes have the improved physical properties, desirable uniformity of wall thickness and other characteristics that are important in reducing weight and increasing strength. The process is ideal for pressure vessels, for other deep-drawn shapes such as rocket and missile bodies and tubes, and for a great variety of containers and enclosures. A brief description of the process is given below. Scaife engineers will be glad to work with manufacturers using or planning to use deep-drawn shapes.
Starting with a circular sheet of steel—
a cup is formed by a conventional drawing operation.
A continuation of this pressing operation turns the cup "inside out" without removing it from the dies—
completing—in a single stroke—a deep-drawn shape having remarkably uniform wall thickness.
The Scaife Reverse-Draw process is suitable for the production of shapes having cross-sections that are circular, oval or rectangular. They can be made with one end completely closed and with the other end flanged or straight. Shapes up to 36 inches maximum diameter can be formed of ferrous and non-ferrous materials, with wall thicknesses up to ¼ inch.
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Scaife Company
OAKMONT (PITTSBURGH DISTRICT), PA.
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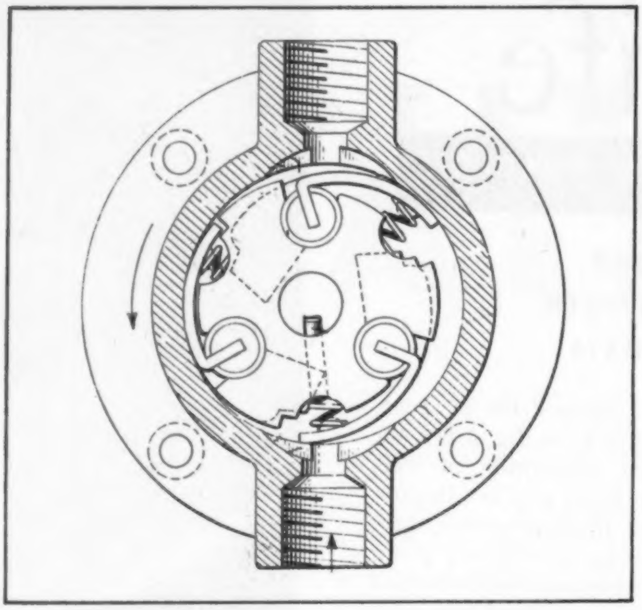
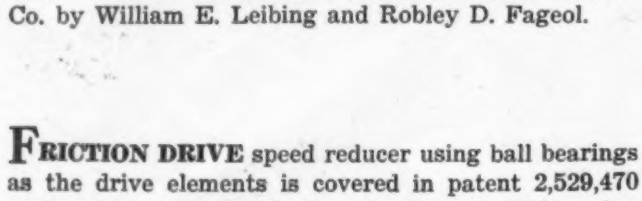


pressure, resulting in increased slip and decreased output pressure. Similarly, weights can be adjusted to give a degree of slippage such that output pressure remains constant over a given speed range. The patent, No. 2,526,621, has been assigned to R. D. Fageol Co. by William E. Leibing and Robley D. Fageol.

FRICTION DRIVE speed reducer using ball bearings as the drive elements is covered in patent 2,529,470 assigned to A. O. Smith Corp. by Irvin L. Elder. Applicable to small motor-driven fans, blowers, etc., the device uses a one-piece, grooved inner ball race keyed to the motor shaft and a split, stationary outer race. Balls carried between the two races rotate a ball cage



on the output shaft at a reduced speed depending on motor speed, race diameters and ball size. Splitting the outer race permits parts to float axially to reduce wear and enables sufficient pressure to be exerted on the balls by a simple spring washer.

Three-Relay Circuits

(Continued from Page 124)

lays 1 to 4 are placed on the sides of the square while relays 5 to 8 are on the half-diagonals, numbered in the same rotary direction. An example is illustrated in *Fig.* 2.

The use of a prime (′) indicates a *complementary relay.* Thus X' is *on* when X is *off* and X' is *off* when X is *on.* A "1" in the table means to close the relay while a "0" means to keep it permanently open. For example, the circuit whose test number is 147 (see TABLE 1) is as shown in *Fig.* 3.

DETERMINING FORMULA BY USE OF MATRICES: The response of a three-relay circuit to the eight combinations of the individual relay conditions gives rise to an eight-place binary number as shown in the second column of TABLE 1. This binary number may also be thought of as a one-rowed binary matrix, called the *test matrix,* designated also by T. This matrix may then be multiplied by a square binary matrix having eight columns and eight rows, called a *conversion matrix, C*. The product of T multiplied by C produces another matrix called the *formula matrix, F*. The eight numbers of the one-rowed matrix F form a binary number whose decimal equivalent is the F of TABLE 1.

The structure of the conversion matrix is formed by building up the following series of matrices all having the same generic form beginning with

$$C_1 = \begin{bmatrix} 1\,0 \\ 1\,1 \end{bmatrix}$$

followed by

$$C_2 = \begin{bmatrix} C_1 0 \\ C_1 C_1 \end{bmatrix} = \begin{bmatrix} 1\,0\,0\,0 \\ 1\,1\,0\,0 \\ 1\,0\,1\,0 \\ 1\,1\,1\,1 \end{bmatrix}$$

and then

$$C_3 = \begin{bmatrix} C_2 0 \\ C_2 C_2 \end{bmatrix} = \begin{Bmatrix} 1\,0\,0\,0 & 0\,0\,0\,0 \\ 1\,1\,0\,0 & 0\,0\,0\,0 \\ 1\,0\,1\,0 & 0\,0\,0\,0 \\ 1\,1\,1\,1 & 0\,0\,0\,0 \\ 1\,0\,0\,0 & 1\,0\,0\,0 \\ 1\,1\,0\,0 & 1\,1\,0\,0 \\ 1\,0\,1\,0 & 1\,0\,1\,0 \\ 1\,1\,1\,1 & 1\,1\,1\,1 \end{Bmatrix} \qquad (5)$$

For a three-relay circuit, C_3 is the proper conversion matrix. A conversion matrix for any number of relays can be constructed by successive use of the recursion formula

$$C_n = \begin{bmatrix} C_{n-1}\,0 \\ C_{n-1}\,C_{n-1} \end{bmatrix} \qquad (6)$$

Example: Consider a circuit whose response to the eight individual relay combinations is 11010111, which corresponds to a test number of 215 as shown in TABLE 1. The test matrix is [11010111]. Multiplying this by C

$$[1\,1\,0\,1\,0\,1\,1\,1] \begin{Bmatrix} 1\,0\,0\,0\,0\,0\,0\,0 \\ 1\,1\,0\,0\,0\,0\,0\,0 \\ 1\,0\,1\,0\,0\,0\,0\,0 \\ 1\,1\,1\,1\,0\,0\,0\,0 \\ 1\,0\,0\,0\,1\,0\,0\,0 \\ 1\,1\,0\,0\,1\,1\,0\,0 \\ 1\,0\,1\,0\,1\,0\,1\,0 \\ 1\,1\,1\,1\,1\,1\,1\,1 \end{Bmatrix} = [0\,0\,1\,0\,1\,0\,0\,1] \qquad (7)$$

we obtain $F = [00101001]$ which corresponds to a formula number of 41.

The formula matrix may now be multiplied by a *variable matrix* (see next paragraph) to produce the formula itself:

$$[0\,0\,1\,0\,1\,0\,0\,1]\begin{Bmatrix} XYZ \\ XY \\ XZ \\ X \\ YZ \\ Y \\ Z \\ 1 \end{Bmatrix} = XZ + YZ + 1 \qquad (8)$$

Thus, a circuit whose test responses yield a binary number whose decimal form is 215 has a formula number of 41 and a formula which is $XZ+YZ+1$, as can be verified from TABLE 1.

GENERAL EXPANSION THEOREM: (See Appendix for proof) The formula for a circuit of n relays is given by

$$f[X_1, X_2, ..., X_n] = T_n \times C_n \times V_n$$

where T_n is a one-rowed test matrix of 2^n numbers representing the responses to the 2^n combinations of the individual relays ranging from all *on* to all *off*, C_n is the 2^n by 2^n square conversion matrix given by Equations 5 and 6, and V_n is a one-columned variable matrix formed by building up a series beginning with

$$V_1 = \begin{bmatrix} X_1 \\ 1 \end{bmatrix}$$

followed by

$$V_2 = \begin{Bmatrix} X_2V_1 \\ V_1 \end{Bmatrix} = \begin{Bmatrix} X_2X_1 \\ X_2 \\ X_1 \\ 1 \end{Bmatrix}$$

and then

$$V_3 = \begin{Bmatrix} X_3V_2 \\ V_2 \end{Bmatrix} = \begin{Bmatrix} X_3X_2X_1 \\ X_3X_2 \\ X_3X_1 \\ X_3 \\ X_2X_1 \\ X_2 \\ X_1 \\ 1 \end{Bmatrix} \qquad (9)$$

with the recursion formula:

$$V_n = \begin{bmatrix} X_nV_{n-1} \\ V_{n-1} \end{bmatrix} \qquad (10)$$

INTERCHANGEABILITY THEOREM: (See Appendix for proof) If two n-relay circuits have the test number of one equal to the formula number of the other, then the test number of the latter equals the formula number of the former.

Example: Referring to TABLE 1, choose circuit A having a test number of 38, $T_A = 38$. This circuit has a formula number of 198, $F_A = 198$. Now looking up circuit B having a test number of 198, $T_B = 198$, it is found that its formula number is 38, $F_B = 38$.

Application of Interchangeability Theorem: The interchangeability theorem was useful in constructing and checking TABLE 1 and also for the quick determination of a circuit having a specified formula.

The desired formula will, of course, depend on the design problem at hand and is chosen as the result of experience with the performance of similar circuits. For example, suppose a circuit is desired whose form-

ula is $XZ + Y + 1$. To find F let $X = 16$, $Y = 4$, and $Z = 2$, obtaining $F = 32 + 4 + 1 = 37$. In TABLE 1 it is found that the circuit having a test number of 37 has a formula number of 147. Thus, again using TABLE 1 to find the circuit whose test number is 147, this circuit has a formula number of 37 and a listed formula $XZ + Y + 1$. The final entries for this circuit give the eight relays for the master circuit as follows: Y' X' 0 Y 0 Z' X Z so the desired circuit whose formula is $XZ + Y + 1$ is as shown in *Fig.* 3.

The test number for $XZ + Y + 1$ could, of course, be obtained by using the eight combinations of X, Y and Z beginning with $X = 1$, $Y = 1$, $Z = 1$ and ending with $X = 0$, $Y = 0$, $Z = 0$ and forming a binary number of eight digits and converting to the decimal notation. With TABLE 1 at hand, however, the interchangeability theorem provides a much quicker method in all but the simplest formulas.

EXTENSION TO FOUR RELAYS: In order to duplicate a circuit containing four relays, W, X, Y and Z, close relay W and obtain the eight test results for X, Y, and Z, refer to TABLE 1 to obtain the proper circuit, C. Then open relay W, repeat the eight combinations of X, Y and Z, and obtain circuit D by the use of the test results tabulated in TABLE 1. The desired circuit is W in series with C in one branch of a parallel circuit having W' in series with D in the other branch. A complete list of four-relay circuits would contain 2 raised to the 2^4 power (2^{16}) or 65,536 distinct circuits. The number of circuits in a nine-relay list would be 2 raised to the 2^9 power (2^{512}), a 155-digit decimal number which must remain only a mathematical curiosity.[3]

CONCLUSION: The general expansion theorem provides a method of obtaining the odd-even algebra formula for a circuit with any number of relays from a knowledge of the circuit's responses to all possible combinations of the individual relays. For three-relay circuits TABLE 1 tells precisely how a circuit having any of the 256 responses can be wired. The notions of a binary number system and of matrix representation have been introduced for simplicity of statement but these notions also point the way for future applications of odd-even algebra to relay analysis.

Appendix

PROOF OF GENERAL EXPANSION THEOREM: For $n=1$, the simple expansion theorem was stated and proved in the previous article.[1] By mathematical induction, it will be assumed that the theorem holds for $n-1$ and proved that it holds for n. For this purpose write T_{n-1}^1 for the value of T_{n-1} when $X_n = 1$ and T_{n-1}^0 for the value of T_{n-1} when $X_n = 0$. With this notation and the recursion relations for C_n and V_n the theorem for n relays is expressed as

$$f[X_1, X_2, \ldots, X_n] =$$

$$[T_{n-1}^1 \; T_{n-1}^0] \begin{bmatrix} C_{n-1} & 0 \\ C_{n-1} & C_{n-1} \end{bmatrix} \begin{bmatrix} X_nV_{n-1} \\ V_{n-1} \end{bmatrix} \quad \text{.........(11)}$$

It is necessary only to show that Equation 11 is true for $X_n = 0$ and for $X_n = 1$. For $X_n = 0$, Equation 11 reduces to

$$f[X_1, \ldots, X_{n-1}, 0] =$$

$$[T_{n-1}{}^1 \, T_{n-1}{}^0] \begin{bmatrix} C_{n-1} & 0 \\ C_{n-1} & C_{n-1} \end{bmatrix} \begin{bmatrix} 0 \\ V_{n-1} \end{bmatrix} \quad \ldots\ldots (12)$$

$$f[X_1, \ldots, X_{n-1}, 0] =$$

$$[(T_{n-1}{}^1 + T_{n-1}{}^0)C_{n-1} \;\; T_{n-1}{}^0 C_{n-1}] \begin{bmatrix} 0 \\ V_{n-1} \end{bmatrix} \quad \ldots\ldots (13)$$

$$f[X_1, \ldots, X_{n-1}, 0] = T_{n-1}{}^0 \, C_{n-1} \, V_{n-1} \quad \ldots\ldots (14)$$

Equation 14 is true because of the assumption of $X = 0$ and because the theorem is true for $n - 1$.

On the other hand, for $X_n = 1$ multiply Equation 11 as follows:

$$f[X_1, \ldots, X_{n-1}, 1] =$$

$$[T_{n-1}{}^1 \, T_{n-1}{}^0] \begin{bmatrix} C_{n-1} & 0 \\ C_{n-1} & C_{n-1} \end{bmatrix} \begin{bmatrix} V_{n-1} \\ V_{n-1} \end{bmatrix} \quad \ldots\ldots (15)$$

$$f[X_1, \ldots, X_{n-1}, 1] = [(T_{n-1}{}^1 + T_{n-1}{}^0) \, C_{n-1} \; T_{n-1}{}^0 \, C_{n-1}] \begin{bmatrix} V_{n-1} \\ V_{n-1} \end{bmatrix} \quad \ldots\ldots (16)$$

$$f[X_1, \ldots, X_{n-1}, 1] = (T_{n-1}{}^1 + T_{n-1}{}^0 + T_{n-1}{}^0) C_{n-1} \, V_{n-1} \quad \ldots\ldots (17)$$

Because the last two terms in the parenthesis on the right side of Equation 17 are to be added by odd-even algebra, their sum will be zero and

$$f[X_1, \ldots, X_{n-1}, 1] = T_{n-1}{}^1 \, C_{n-1} \, V_{n-1} \quad \ldots\ldots (18)$$

which is true because $X_n = 1$ and the theorem holds by assumption for $n - 1$.

Proof of Interchangeability Theorem: Denoting the circuits by A and B the hypothesis is that

$$T_A = F_B \quad \ldots\ldots (19)$$

By the expansion theorem

$$F_A = T_A C_n \quad \ldots\ldots (20)$$

Combining Equations 19 and 20

$$F_A = F_B C_n \quad \ldots\ldots (21)$$

Also by the expansion theorem,

$$F_B = T_B C_n \quad \ldots\ldots (22)$$

From Equations 21 and 22,

$$F_A = T_B C_n{}^2 \quad \ldots\ldots (23)$$

The square of any conversion matrix is the identity matrix, I, having 1 on the main diagonal and 0 elsewhere. This is proved by mathematical induction using Equations 5 and 6.

$$C_n{}^2 = \begin{bmatrix} C_{n-1} & 0 \\ C_{n-1} & C_{n-1} \end{bmatrix} \begin{bmatrix} C_{n-1} & 0 \\ C_{n-1} & C_{n-1} \end{bmatrix} =$$

$$\begin{bmatrix} C_{n-1}{}^2 + 0 & 0 \\ C_{n-1}{}^2 + C_{n-1}{}^2 & C_{n-1}{}^2 \end{bmatrix} \quad \ldots\ldots (24)$$

Inasmuch as odd-even algebra is used in adding matrices, the sum of $C_{n-1}{}^2$ added to itself is 0, so that $C_n{}^2$ is an identity matrix if $C_{n-1}{}^2$ is an identity matrix because there are zeros on the nondiagonal portions of the last matrix in Equation 24. The fact that $C_1{}^2$ and $C_2{}^2$ are identity matrices is easily verified by use of Equation 5. As $C_n{}^2$ is the identity matrix for n variables, Equation 23 becomes

$$F_A = T_B \quad (25)$$

which is the required result. Thus the theorem is proved. In the foregoing equations the T's and F's are considered to be matrices, but the results hold for either the binary or decimal forms of T and F.

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2. Swannack, J. D.—"Beam Deflections Solved with Matrices," MACHINE DESIGN, Sept., 1949.
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Design Abstracts

(*Continued from Page* 175)

human characteristics. Although the fundamental scientist is by no means as isolated as he was a generation ago, he still has a substantial amount of the aura of the ivory tower. He usually is a strong individualist and, perhaps with reason, feels that his role in the field of science is the most important because it is the most basic. Hence, he is prone to exhibit the same type of smugness as the struggling artist who contends that the world does not understand him because it is too stupid. The true denizen of the ivory tower looks down upon the engineers and technicians and production lines and the whole idea of utilitarianism. This is intended to be a condemnation, but certainly not a blanket one, for it does not apply to all, probably not even to a majority of the fundamental scientists.

The NIH factor (not invented here) is one of the dominant deleterious items in the course of new developments. The fact that it has never been measured

". . . what can I find wrong . . . so I can do it differently . . ."

—no one has yet thought up an applicable psychological unit—does not decrease its importance. The incidence of a large NIH factor is particularly high among engineers. When a development team, which usually consists of engineers, receives or is assigned a project which has previously gone through the role of applied research, the first reaction is, "What can I find that is wrong about this so that I can start over and do it differently?" This negative attitude is probably the result of an inferiority complex on the part of the engineers, whether recognized or not. They, too, tend to be individualists and also are usually deficient in fundamental knowledge of the natural world. As a result they go to great lengths to try to find some way to identify the project with a contribution of their own and they usually do it

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LULL Shoveloader

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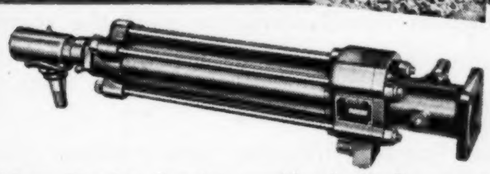

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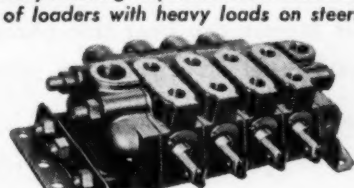

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

by tearing down the structure that has been handed to them and putting it back together—always with a loss of time and frequently with a degradation of results. These attitudes between groups which are basically in conflict are the ones that must be modified to a substantial degree if we are to make research and development as effective as possible.

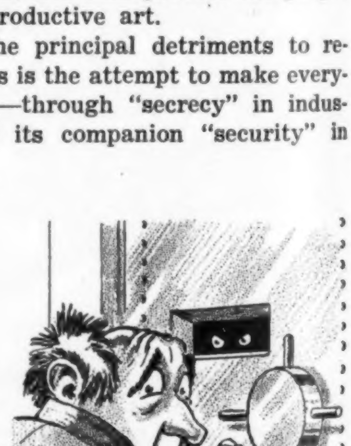
Having extolled the virtues and the necessity of cooperation within groups and a sort of supercollaboration among groups, I now wish to voice a warning as to the inherent and real dangers of such a system. Research, particularly fundamental research, like art, is basically the product of individual creative minds. All the scientific paraphernalia in the world manned by the world's best but uninspired collection of technological teams will not by themselves produce a single new scientific discovery. And without discoveries we will soon be scientifically bankrupt.

There is nothing basically new in this conflict. A certain loss of individual action, like traffic lights, is one of the penalties of civilization. In the case of scientific research, the problem is more serious than in more mundane and routine occupations, for here individual creativeness is a necessity. And creativeness goes dead under excessive restrictions. There's no use trying to solve the problem by edicts and compulsion. There's no point in beating a dead horse—you can only make soap out of him.

No pat or complete answer to the situation is available or ever will be. It is primarily a matter of conditioning and adjustment. Management of research can go a long way toward respecting the individual, without reverencing him, and thus provide the proper environment for his productive art.

Ironically, one of the principal detriments to research accomplishments is the attempt to make everything safe and secure—through "secrecy" in industrial laboratories and its companion "security" in military circles. People being the way they are, industry has found it necessary to maintain strict secrecy around embryonic developments until proper proprietary position has been established by patents, or otherwise. But this can be and usually is carried to undesirable lengths, detrimental to both the secretor and the public. As C. F. Kettering has sagely remarked, "When you lock the laboratory door, you lock out a great deal more than you keep in."

". . . secrecy around developments can be overdone . . ."



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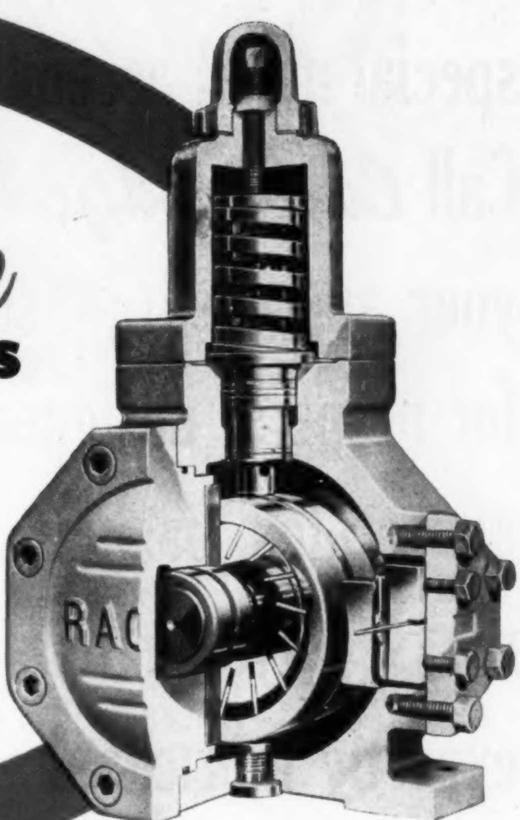

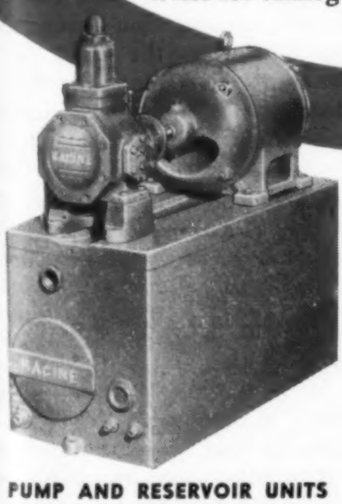

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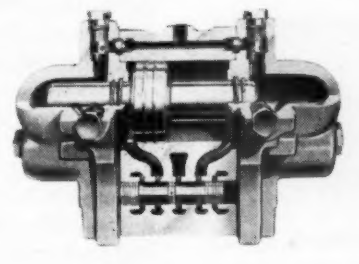

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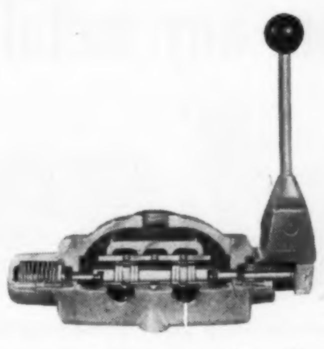

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restricted, confidential, secret or top secret, in order not to give aid and comfort to the enemy. This is necessary up to a point, but the process of maintaining security carries in its framework a national hazard which the denizens of military security apparently seldom realize. All that can be gained by security is an increment of time and usually a rather small increment at that. The scientific jewel of rare price which is being guarded most assiduously quickly becomes a hollow shell of no value, just as soon as the enemy has independently thought of something just as good, or better.

Security and Progress Must Balance

This is a dilemma of extreme importance which has not been solved to the satisfaction of the scientists and I doubt if it is satisfactory to most military personnel. Some items, particularly as they approach application, must be guarded and guarded assiduously in the interest of national defense, but the matter is often seriously overdone. The short-time benefits that may be gained by secrecy of something new must be weighed against the inevitable hindrance to the progress of the development of that which is still newer and better. Achieving the proper balance between these two opposing factors is, or should be, a matter of grave national concern. Adopting the wrong pattern can readily lead to national calamity.

In view of the international situation—economically, sociologically and militarily—the road to the solution of greater team effectivity in utilitarian research may quite literally be the road to survival. No exact and rigid solutions to such problems can be found. They are not the kind of problems which have the answers spelled out in handbooks. The essence of the solution is the attaining and maintaining of really effective collaboration among teams.

Democracy in Science

Collaboration can be achieved. Dramatic accomplishments of the Office of Scientific Research and Development during World War II, in the successful development of the proximity fuse, improved radar and the atomic bomb, called for extreme team collaboration among universities, industry and the military. This is essentially the democratic approach. True, you do not decide on scientific truths by counting noses, as you do in political democracy, but the essence of democracy involves the right to be heard and the right to participate in planning, and that can be pursued in research activities.

There are those who believe that Hitler failed because he put his scientists in the same totalitarian strait jacket as his political victims. There are those who believe that, in the long run, scientists cannot be sufficiently effective under Communist totalitarianism to outdo the researchers under democratic regimes. Ultimately, democracy, in its fumbling way, is infinitely stronger in those activities, such as research, which call for individual creativeness. This expression of faith certainly does not point up the solutions of the present problems, but perhaps it does

point out the direction in which the solutions may be found. When everyone realizes what the problems are, has analyzed them and has agreed on the method of attack, then the battle is half won—and that is a fairly good start.

From a paper presented at the Annual Meeting of AAAS (Engineering Section) in joint session with Cleveland Engineering Society in Cleveland, December 27, 1950.

Designing Construction Equipment for Arctic Service

By R. W. Beal
Engineer Center and Fort Belvoir
Fort Belvoir, Va.

IN THE preparation of machinery for low-temperature operation many technical problems appear. Lubrication of engines, gears, bearings, etc., becomes a most critical problem, both because of the changed characteristics of the lubricant itself as a lubricant, as well as the difficulty of distributing the lubricant to critical points. Characteristics of the engine coolant itself may change and, in addition, the cooling system, which in conventional equipment is designed to do a cooling job, is completely out of balance where the problem in cold-weather operation is to keep an engine warm rather than cold.

Fuels present a very immediate critical problem in that gasoline fails to vaporize and diesel fuel refuses to flow at these extremely low temperatures. Cranking systems normally provided on construction machinery are completely inadequate for cranking under cold conditions, both because cranking demand is greater and performance of the cranking device itself is lowered. Materials are often adversely affected by low temperatures. Metals become brittle; belts and hoses become stiff and may require substitution of chain or gear drives.

Individuals in cold weather clothing require a great deal more space than those dressed for temperate climates. The comparisons in TABLE 1 are striking illustrations of the extent of this increase in bulk, which requires special consideration during the winterization of equipment. Adequate sizes of, and spacing between handles, nuts, levers, pedals, etc., are continually being compromised with the sizes of mittens and boots.

One of the operational problems contributing most

Table 1—Space Requirements of Arctic Clothing

Parts Measured	With Warm Weather Clothing (Inches)	With Arctic Weather Clothing (Inches)
Chest	37	61
Hips	37	64
Ankle	9	28
Head	23	38
Wrist	7½	21
Foot (length)	11	14
Foot (width)	3½	5
Breadth across shoulders	18	32
Thickness through chest	10	17

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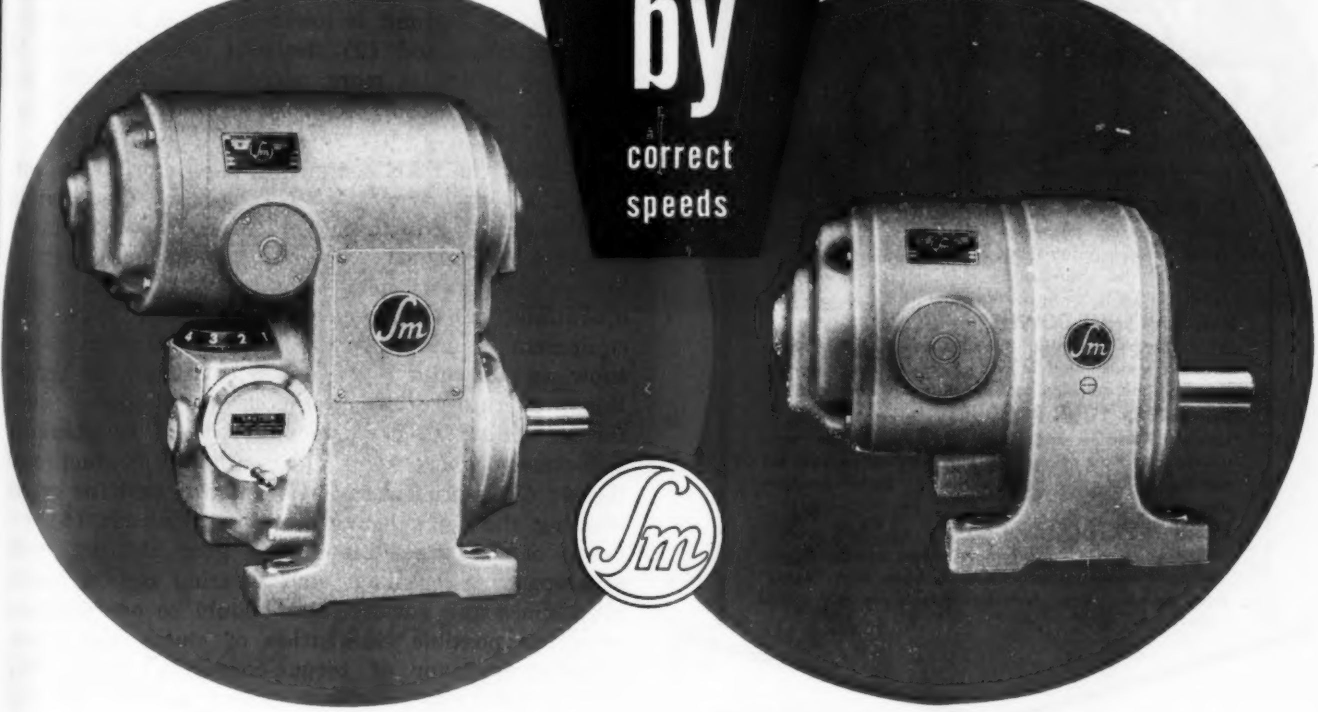

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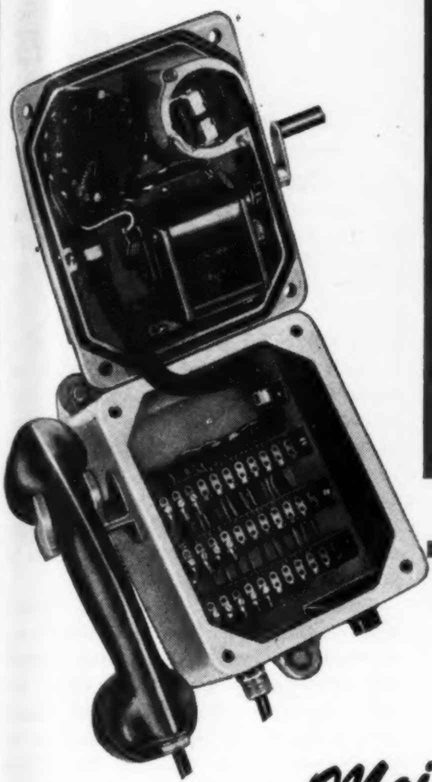
to the difficulty of low-temperature operation is the actual lowering of personnel efficiency. Even simple tasks take several times as long to perform under extreme cold conditions as under temperate conditions. In addition, actual jobs to be done, such as maintenance, are greatly increased in number and are more difficult under these adverse conditions. Also, the actual on-the-job production by a piece of construction equipment, even when operating satisfactorily mechanically, is greatly reduced by a combination of two factors: (1) the actual mechanical efficiency of the unit is lowered by the cold operating conditions, and (2) the unit is called upon to do a job which is more severe than normally encountered because of the frozen condition of all materials.

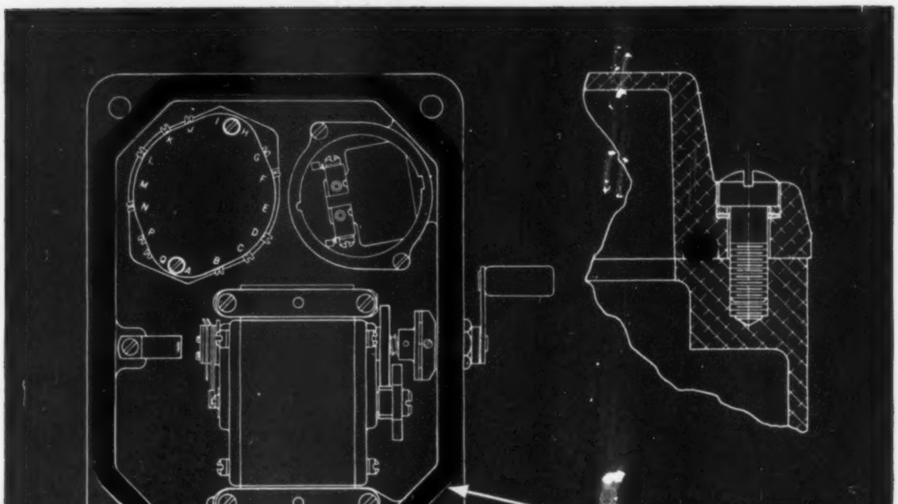
An unofficial SAE committee, whose members witnessed several Army Ground Forces operations in Alaska and the northern part of the United States, stated as a general criterion that temperatures as low as -60 F may have to be provided for in winter operations, and more specifically, that (1) military equipment is under-powered for operating in heavy snow and on hills; (2) under extreme cold conditions, operators cannot remove their gloves even for an instant to perform any type of maintenance adjustment where their fingers might contact cold metal; (3) sufficient room is not provided for crews wearing the thick heavy clothing required; (4) because of the great amount of gear shifting, with accompanying breakage and wearing out of parts, all engines and power trains should be overdesigned with the possible elimination of clutch and transmission in favor of torque-converter drives; (5) because of bulky clothing, heavy mittens, etc., all controls, pedals, handles, knobs, etc., should be larger and spaced farther apart; (6) better cab defrosting methods should be provided.

From a paper entitled "Winterization of Construction Equipment," presented at the SAE National Tractor Meeting in Milwaukee, September 12-14, 1950.

They Say . . .

"We can't expect a gimmick to take care of the selection of supervisory personnel. This brings up the question of testing as an aid in finding the right man for a job. I'd like to caution you about relying too heavily upon psychological tests. Many such devices have tremendous promise and possibilities—tremendous implications—but nothing more. They are not panaceas or miracle workers. They are not a substitute for the personal contact of the interview: they are a supplement to it. Certainly, we need simple tests to determine the basic intelligence of a supervisory prospect; we need tests that will show his aptitudes and interests. But, above all, we need to talk to the man. We need to learn something about his past experience, his attitudes, his likes and dislikes. We need personal contact and we don't get it if we leave selection entirely up to the personnel tester."—E. H. Reed, *manager, education and training, International Harvester Co.*





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PROFESSIONAL VIEWPOINTS

". . . ingenious method of three dimensional photoelasticity"

To the Editor:

I cannot refrain from commenting on the December issue of MACHINE DESIGN. I have watched with such interest your magazine grow from its meager but brave beginnings in the early stages of the depression that it is with a feeling of almost personal pride that I see the results of this growth as evidenced, in particular, by this issue. The many fine articles you are carrying are witness to the dominant position you have attained among commercial engineering journals. My warmest congratulations to you and your fine staff.

Two items, in particular, merit special attention. One is Rudorf's article on safety. As he states, simple but obvious design safety rules are often ignored. This has been tragically pointed up here in Chicago by the recent flash fire on the North Shore Line. Apparently this accident resulted from the absence of simple interlocking controls in the electrical system which permitted the motorman to "notch" on his power while a man in another part of the train was switching over from trolley to third rail pick-up. Certainly an unbelievablo violation of design safety rules.

The other article is the ingenious method of three dimensional photoelasticity described by Durelli and Lake. This method promises much for the future of this experimental method of elastic analysis. It is certainly untrammelled thinking to take what has been considered a troublesome and annoying defect and recognize in it such possibilities for profitable research. This article provokes a number of questions. Presumably the Catalin plastic used is widely different in its characteristics from the Bakelite BT-61-893 formerly so commonly used for photoelastic work, although both are phenol-formaldehydes. We used to find a fringe value near 86 psi stress difference as against the initial value of the Catalin of 40 (presumably). Moreover, we did not experience the very rapid initial optical creep shown in *Fig.* 3, possibly because of our relatively high (300 F) anneal temperature. Is this, then, essentially a different material photoelastically even though both are in

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the phenol group?

We find considerable difficulty correlating *Figs.* 1 and 2 with the curve of *Fig.* 3. From the latter the fringe value drops from, say, 16 (shear) to about 6½, which should raise the fringe value at the center of the disk in *Fig.* 1*a* from 2¾ to about 6¾, rather than the 3⅞ shown in *Fig.* 1*b*. Likewise, comparing *Fig* 1*c* with *Fig.* 1*b*, the former should show 3⅞ x 6/4½ = 5⅛, instead of the 4¾ shown. Apparently there is something here we misunderstand.

We would also be interested in knowing whether there is creep of the residual pattern; that is, does the specimen tend to return to an optically "unstressed" condition? If so, at approximately what rate?

It would appear that the residual pattern is equal to the "creep" pattern, that is, the final loaded pattern minus the initial loaded pattern. Is this generally true?

From the pictures shown it would seem that the authors ascribe an accuracy to the method that scarcely seems warranted; unless, perhaps some interference method was used to determine fractional fringe levels.

Last, we should like to inquire if the authors propose to publish further details of their very excellent work and, if so, where?

—R. E. ORTON
Assistant General Manager
Orton Crane & Shovel Co.
Chicago, Ill.

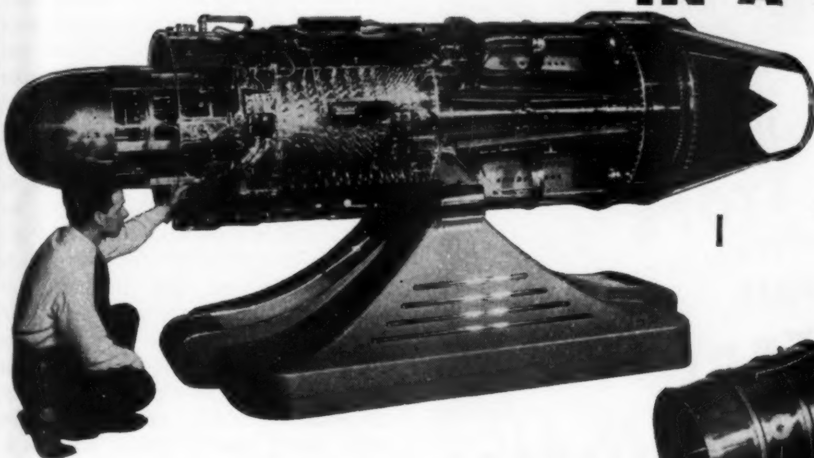
". . . Catalin used in tests differs widely from Bakelite"

To The Editor:

Mr. Orton has raised a number of interesting points in his letter. We shall attempt to answer his questions in the order in which they were asked. He is quite correct in his statement that the Catalin used in our tests differs widely from Bakelite (Catalin) BT 61-893. The latter plastic is a glycerin phthallic anhydride rather than a phenol formaldehyde.

It is not surprising that the data shown in *Fig.* 3 does not agree with that in *Figs.* 1 and 2 since *Fig.* 3 was based on a tensile specimen cut from a different sheet of material and subjected to a different annealing cycle. Perhaps the difference should have been emphasized but at the time of writing, our thought in presenting *Fig.* 3 was merely to illustrate the general form of the creep curve. The creep of Catalin depends on the state of cure of the material in a way which, as yet, is unpredictable by us. It is therefore necessary to autocalibrate each test either by taking as a standard some point in the model at

RINGS THAT GO IN A STRAIGHT LINE



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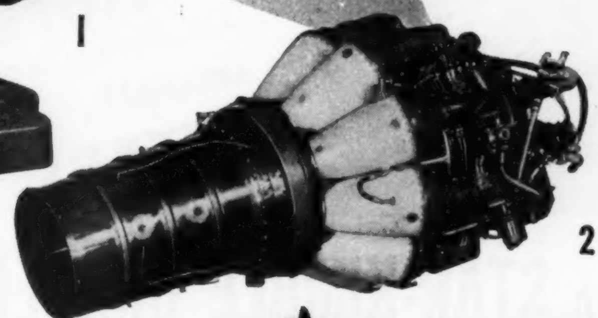

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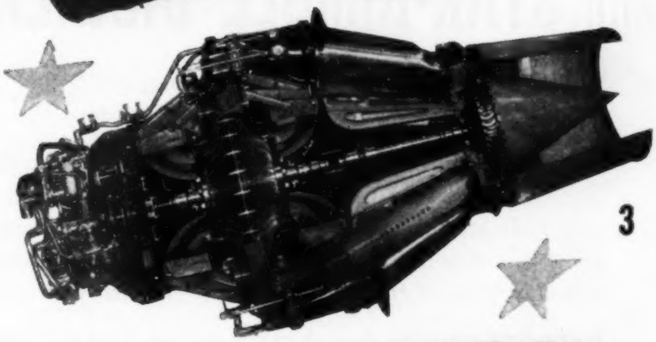

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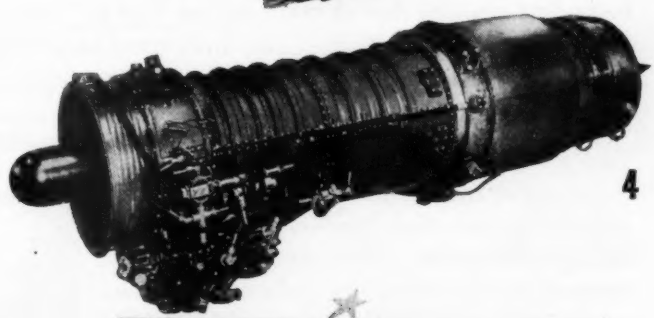

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which the stresses may be computed by the usual formulas of elasticity, as was suggested in the paper, or by applying the load through a suitable calibration specimen cut from the same sheet and subjected to the same thermal history as the model.

As is indicated by *Fig.* 3, the residual pattern disappears with time after unloading but here again each piece of Catalin is a law unto itself. In some cases the number of fringes may be reduced in four or five hours to one quarter of the number present immediately after unloading. In other cases one half the fringes may remain after a month. The assumption that the residual pattern is equal to the creep pattern is certainly a good working rule, although we have not attempted to check it numerically.

As to the question of accuracy, we make regular use of both light and dark field stress patterns, thus in a sense measuring fractional orders. In general, we find that this results in sufficient points to permit us to plot a rather accurate stress distribution curve which may be extrapolated to the boundry with an accuracy which depends primarily on the precision with which the boundary may be located. Usually the boundary fringe order can be determined within five percent. In the case of a calibration specimen where we have very little stress gradient, and hence find it impossible to determine fractional order by extrapolation of a curve, we employ the Tardy method of compensation in which the fractional order is proportional to the number of degrees through which the analyzer must be rotated to produce extinction at the point in question.

A somewhat more detailed description of this work will appear soon in the Proceedings of the Society for Experimental Stress Analysis, probably in the next issue. Unfortunately we have not been able to further develop this method of producing a "frozen" pattern because of the pressure of other work.

In conclusion we should like to express our thanks to Mr. Orton for his very complimentary letter and to you for this opportunity to reply to it.

—A. J. DURELLI AND R. L. LAKE
Armour Research Foundation
Illinois Institute of Technology
Chicago, Ill.

". . . overall view a stimulus to the designer"

To The Editor:

The general viewpoint of machine analysis presented by H. Ziebolz in "Systematic Design of Mechanisms" which appeared in your December

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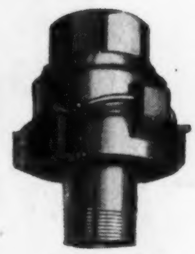

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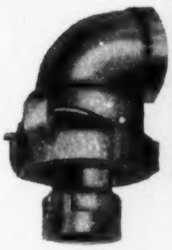

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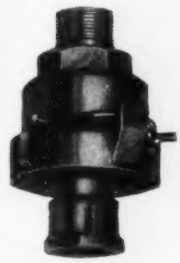

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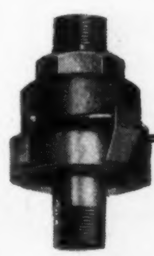

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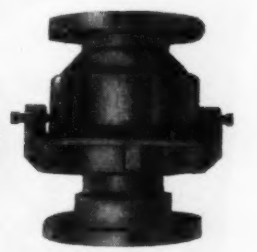

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issue should be a stimulus to many whose thinking is confined to specific machines. By taking such an over-all view the designer may see the mechanism on the board in front of him in a new light and may substitute new components for the present devices under consideration. To this end, the survey of operators suggested by Mr. Ziebolz in his closing paragraph would indeed be of assistance.

Although the application of electrical circuitry to mechanical systems is being made by others as well, the Ziebolz article serves to publicize this trend. The many photographs and schematic sketches demonstrate how general theory should be brought down to specific mechanisms. Just as it sometimes helps to "stand way back and squint" in television reception, so it also helps to get away from the drawing board and visualize the mechanism on it as a special case of such a theory as proposed in your December issue.

The numbering arrangement of the translator map of *Fig.* 2 is particularly strange. A direct left-to-right numbering would be less confusing.

Personally, the reference to LaPlace transforms suggested an investigation in connection with an application of odd-even relay analysis to machine theory. There still remains a difficulty in regard to parallel connections, but it is reasonable to assume that this article has struck a responsive chord for many others who also look to MACHINE DESIGN for new and helpful ideas at all levels of design experience.

—EDWARD C. VARNUM
Barber-Colman Company
Rockford, Ill.

"... reason for strange arrangement"

To the Editor:

It is very gratifying to see that the article has created so much interest and Mr. Varnum's comments are greatly appreciated.

The only comment I would like to make is with regard to *Fig.* 2 and the number system chosen. The reason for this strange arrangement is that the number of variables which have to be covered is still unknown and this numbering is the only one I can think of which will permit us to continue the numbering without any limit. It is very likely that different designers will be interested in different parameters and the reference system should be such that it can go on indefinitely.

—H. ZIEBOLZ
Askania Regulator Co.
Chicago 11, Ill.

THE ENGINEER'S

LIBRARY

Handbook of Experimental Stress Analysis

Edited by M. Hetenyi, professor of engineering mechanics, Technological Institute, Northwestern University; published by John Wiley & Sons Inc., New York; 1077 *pages,* 6 *by* 9 *inches, clothbound; available through* MACHINE DESIGN, $15.00 *postpaid.*

Written by 31 recognized stress analysts, this book is a unified presentation of all existing experimental methods for the determination of mechanical strength.

Introductory chapters deal with the properties of materials. Here the basic concepts—stress, strain, displacement, elasticity, Poisson's ratio, etc.—are defined and relationships charted. Other properties essential to the designer, such as impact, creep, fatigue, hardness, etc., are explained concisely.

Major content deals with testing machines—static, dynamic and special; mechanical gages and extensiometers; optical methods of strain measurement; electrical - resistance gages and circuits; electric-inductance gages; motion measurements; strain rosettes; working stresses; residual stresses; methods of crack detection; interpretation of service factors; brittle models and brittle coating; structural model analysis; analogies; photoelasticity—two and three dimensional; and x-ray analysis. Each discussion includes comments on the proper application of the experimental method, properties tested and evaluation of data derived. Diagrams, charts and photographs are used liberally to support and clarify the discussions.

There are three comprehensive coverages in the appendix relative to the fundamentals of elasticity (Timoshenko), dimensional analysis (Goodier) and the precision of measurements (Hetenyi). Complete and concise, these discussions should prove of value in correlating the practical with the theoretical.

Borne out by the book is the fact that experimental methods, conducted with actual parts under true service conditions, have distinct advantages over the limited applicability of mathematical methods based on simplified assumptions which imply detachment from reality. Advantages

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of the experimental approach become obvious when it is considered that it is possible to determine the stress distribution in a machine part in actual operation without knowing the nature of the forces acting on the part under these circumstances.

□ □ □

Standard Metal Directory

Published by the Atlas Publishing Co. Inc., New York; 818 *pages,* 6 *by* 9 *inches, clothbound; available through* MACHINE DESIGN, $15.00 *postpaid.*

The twelfth edition of this directory is divided into five sections: iron and steel plants; ferrous and nonferrous metal foundries; metal rolling mills; metal rolling plants; and nonferrous metal smelters. Contained are 10,000 detailed reports on American and Canadian plants which are listed both alphabetically and geographically.

Each report gives company name, capitalization, plant equipment, products manufactured, primary and secondary raw materials consumed, and chief personnel. Special lists in the directory include fabricators and distributors of iron and steel products, metal stamping plants, forging manufacturers, diecasting plants, metal powder producers, and aircraft and automotive vehicle manufacturers.

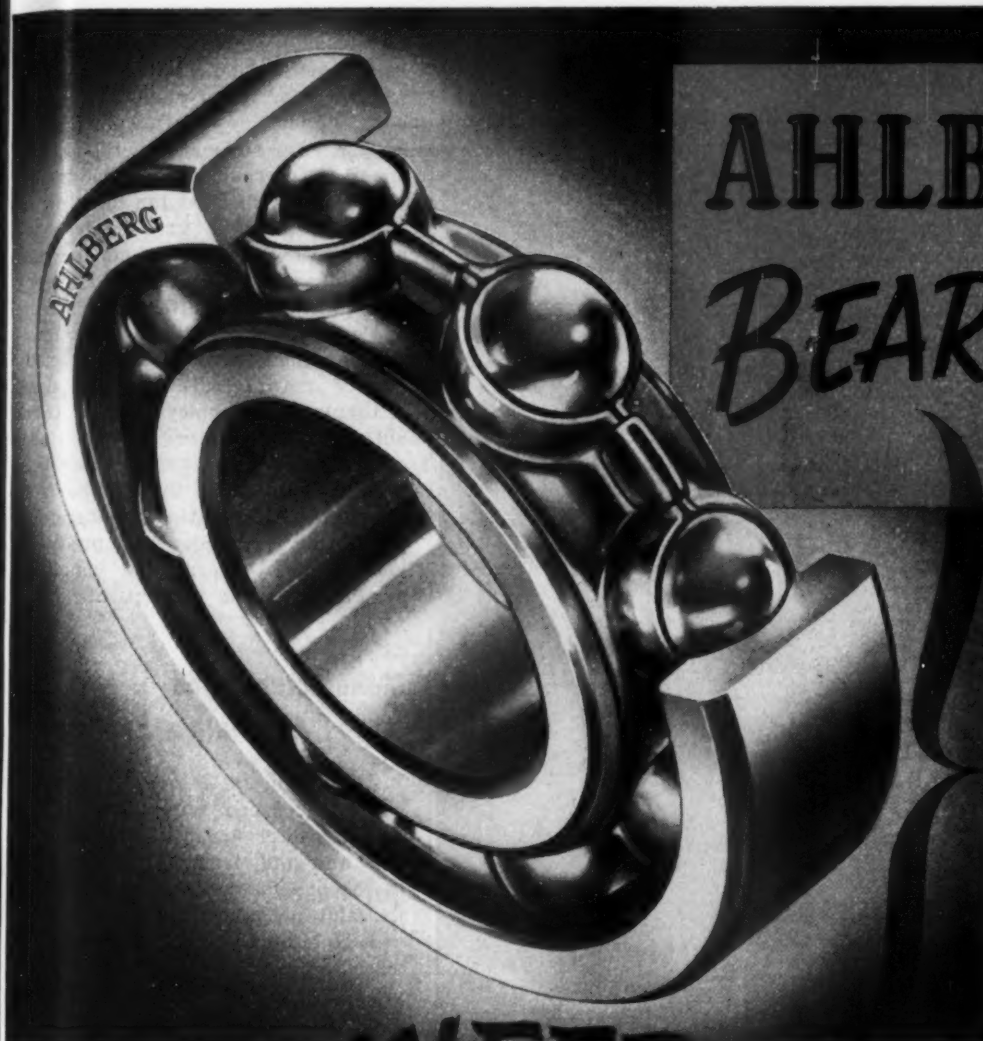
□ □ □

Guillet's Kinematics of Machines

Revised by Austin H. Church, professor of mechanical engineering, New York University; published by John Wiley & Sons Inc., New York: 299 *pages,* 5½ *by* 8½ *inches, clothbound; available through* MACHINE DESIGN, $4.00 *postpaid.*

Presenting concisely the fundamentals of machine kinematics as in previous editions, this fifth edition extends the Guillet approach which is characterized by emphasis on practical applications and their frequent illustration. The book's contents include discussions of general considerations of mechanisms and motions; displacement, velocity and acceleration; instant centers; velocity and acceleration in plane motion; slider-crank mechanisms; cams; rolling contact; gears and gear trains; flexible connectors; and miscellaneous mechanisms.

To those familiar with earlier editions several changes will be evident. Sections on simple harmonic motion and on scale determination



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for velocity and acceleration have been revised. The chapter on velocity and acceleration in plane motion has been largely rewritten, particularly the material on image methods, with an added section on Coriolis' theory. A tabulation method for locating instant centers has been added. Revised proof of Klein's construction and inversions of the slider-crank mechanism are offered. Pressure angle of cams, selection of cam motion, application of cams, and methods of manufacture are explained. A tabulation for epicyclic gear trains with no fixed member has been added; the section on gearing has been revamped to shift the emphasis of gear kinematics to the currently used generating principles for producing gear teeth. Uniform and consistent symbols are used throughout.

Manufacturer and Association Publications

Aluminum Data Book: This 194-page 6 by 9-inch wire bound booklet contains information on aluminum alloys and mill products. Tabular data in the booklet covers physical, chemical and mechanical properties, standard tolerances, weights, standard sizes and production limits, and fabricating data. Included are tables showing relative corrosion resistance, the action of many chemicals on aluminum, elevated and low-temperature properties, fatigue strengths, minimum bend radii, joining methods, finishes for aluminum, and others. In addition, there are 33 pages of explanatory text covering a wide range of related subjects such as the alloy designation system, the temper designation system, heat-treatable and nonheat-treatable alloys, casting alloys, casting methods, and foundry practice. Wrought aluminum mill products are detailed and manufacturing methods described. Fabricating methods for the wrought alloys are discussed, including blanking and forming operations, forging, machining, joining, and surface finishing.

Copies of booklet are obtained by directing company-letterhead requests to the Reynolds Metals Co., 2500 South Third St., Louisville, Ky.

Steel Castings Handbook: Rewritten and reorganized, this 1950 edition brings up to date a comprehensive view of the steel castings industry in terms of products, processes, history, and outlook. Coverage includes types of steel castings, specifications, design considerations, applications, mechanical and physical properties

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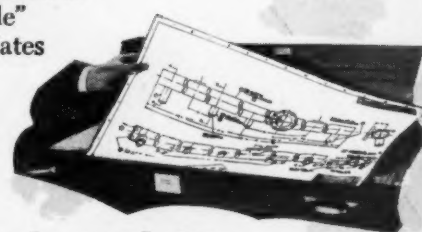

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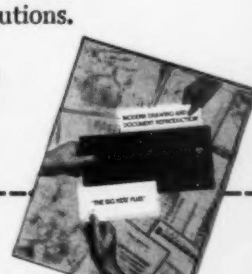

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and other relevant technical data. Discussions concerning steel casting design, variables affecting mechanical properties of steel castings, and engineering properties of cast steels should prove of particular interest to designers. The edition contans 522 pages, 440 illustrations and 120 tables.

Copies of the 1950 edition may be obtained by writing to F. Kermit Donaldson, executive vice president, Steel Founders' Society of America, 920 Midland Bldg., Cleveland 15, O. Price per copy is $4.00.

Government Publications

Handbook of Human Engineering Data for Design Engineers: This handbook is the first systematic treatise on the science of designing mechanical equipment on the basis of detailed studies of human capabilities. It was written by the Tufts College Institute for Applied Experimental Psychology under a research contract with the Navy's Special Devices Center. Intended primarily as a reservoir of factual information for the design engineer, the book is divided into eight broad sections dealing with: the human machine and human engineering; the human body (anthropometrics); characteristics of vision; factors influencing the efficiency of hearing; skin sensitivity and proprioception (space orientation); motor responses; physiological factors (sleep, temperature, drugs, etc.); and intelligence. A glossary of some 500 terms used in human engineering is included as well as an author index and subject index.

Designated PB 100 814, the book contains 370 pages, measures 8½ by 11 inches, and is replete with graphs, charts and tables. The book sells for $5.00 per copy. Orders should be addressed to the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., accompanied by check or money order payable to the Treasurer of the United States.

Analysis of the Effects of Design Pressure Ratio per Stage and Off-Design Efficiency on the Operating Range of Multistage Axial-Flow Compressors—NACA TN 2248 by Melvyn Savage and Willard R. Westphal: An equation is derived which expresses the polytropic efficiency necessary to maintain the design axial-velocity ratio across one or several blade rows of a compressor as a function of the design efficiency, the design static-pressure ratio, and the off-design static-pressure ratio. This equation is applied to the two-dimensional case

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of a compressor rotor and is derived as a function of the stage design parameters. For a symmetrical stage, calculations are completed to determine these hypothetical necessary efficiencies at several off-design inlet axial velocities for a range of design pressure ratios. At high design pressure ratios, the reduction in hypothetical efficiency with increasing inlet axial velocity was small enough to permit a possible matching of blade row and hypothetical efficiencies. The effects of design pressure ratio on axial-velocity change across a rotor at mass flows below design were further investigated by assuming the off-design blade-row efficiency to be constant. Calculations indicated that a greater reduction in axial velocity occurred across rotors having lower design pressure ratios. Hence, if it is assumed that the blade-row efficiency curves for high- and low-pressure-ratio designs are somewhat similar, a multistage compressor composed of high-pressure-ratio stages, operating with constant rotational speed at mass flows below design, will have higher off-design efficiencies and a wider mass-flow operating range than one made up of low-pressure-ratio stages.

Copies of this NACA technical report are obtained by writing to National Advisory Committee for Aeronautics, 1724 F St. NW, Washington 25, D. C.

New Standard

Abbreviations for Use on Drawings ASA Z32.13—1950: Sponsored jointly by the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, this standard is a revision of the 1946 edition, incorporating latest industry-wide practice. It is designed chiefly to aid in the interpretation of industrial drawings prepared by companies and branches of the government. This 1950 edition contains special new sections on abbreviations for colors, valves and screw threads. The section on abbreviations and letter symbols for cable and magnet wire has been enlarged to include colors. More than 200 changes have been made in the abbreviations of the original edition, and more than 40 new abbreviations have been incorporated. Complete agreement on all common words is expected between this standard and military standard MIL-STD-12A when the latter is approved. Copies of the standard may be obtained from the American Standard Association, 70 East 45 St., New York 17, N. Y., at $1.00 per copy.

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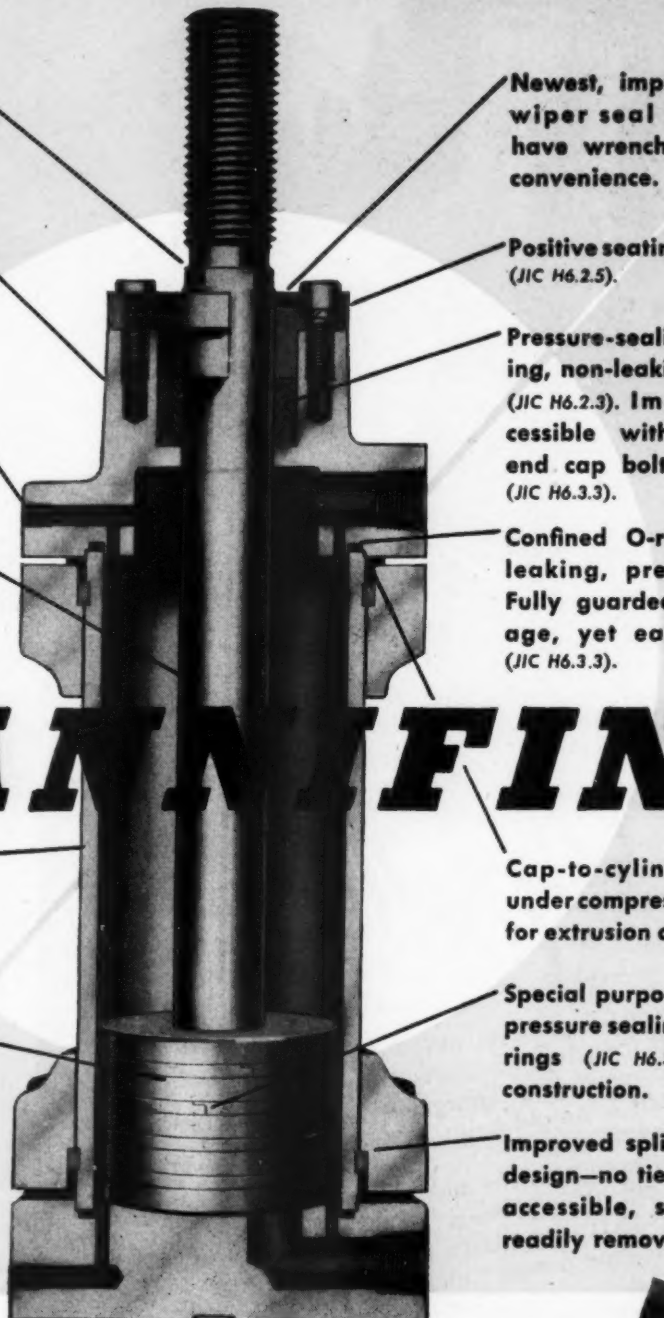

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NEWS

OF MANUFACTURERS

Baldwin Locomotive Works and **Lima-Hamilton Corp.** have announced that their agreement and plan for reorganization is effective. Under the plan, Baldwin changes its name to **Baldwin-Lima-Hamilton Corp.** and acquires all of the assets of Lima-Hamilton in exchange for stock of Baldwin-Lima-Hamilton.

♦

Cleveland Pneumatic Tool Co., Cleveland, O., has a $2,500,000 expansion program underway to boost its output of landing gear and other products. One million of the necessary capital is being privately financed and covers plant expansion, rearrangement and machine tools. The balance covers machine tools being acquired under a government facilities contract. Subject to machine tool availability, the program is expected to be completed by July 15, 1951.

♦

Link-Belt Co., Chicago, Ill., has announced that its wholly owned South African subsidiary, Link-Belt Africa Ltd., incorporated a year ago, has purchased a 12,000 sq ft manufacturing plant. The plant and separate office building are located on a 12-acre plot in Springs, Transvaal, about 28 miles east of Johannesburg, and will be used for the manufacture of conveyor machinery for the South African market.

♦

Westinghouse Electric Corp. will build a new plant for the production of small electric motors. The one-story structure containing both manufacturing and office space will be located in Union City, Ind. Simultaneously, Westinghouse is expanding its Small Motor Division in Lima, O. Two buildings there, totaling some 120,000 additional sq ft, have been leased. The larger building will be used for production of machined parts needed at the main Lima plant for military production, while the second building will be devoted to office and storage use.

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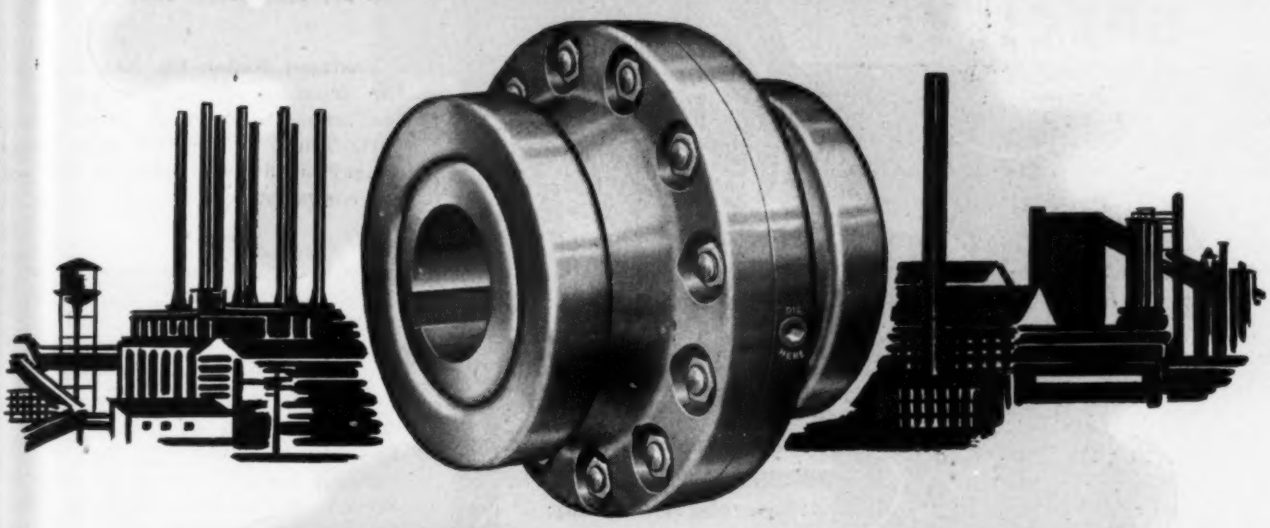

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Eastman Kodak Co. has dissolved the separate corporation status of the Tennessee Eastman Corp., Kingsport, Tenn. The wholly owned subsidiary is now a division of the parent company.

♦

Air Reduction Sales Co., division of Air Reduction Co. Inc., has purchased a site on which will be erected another plant for the manufacture of oxygen and nitrogen. The new plant and facilities, designed by Air Reduction and to be constructed by Koppers Co., Pittsburgh, Pa., will occupy a tract of land covering 23 acres in Butler, Pa. Operation of the plant is expected to begin in the latter part of this year.

♦

H. K. Porter Co. Inc., Pittsburgh, Pa., is continuing its policy of diversification of manufacturing operations. The company recently acquired the Delta Star Electric Co., Chicago, Ill., manufacturer of high-voltage electrical equipment. Porter also produces equipment for the rubber, steel and oil industries.

♦

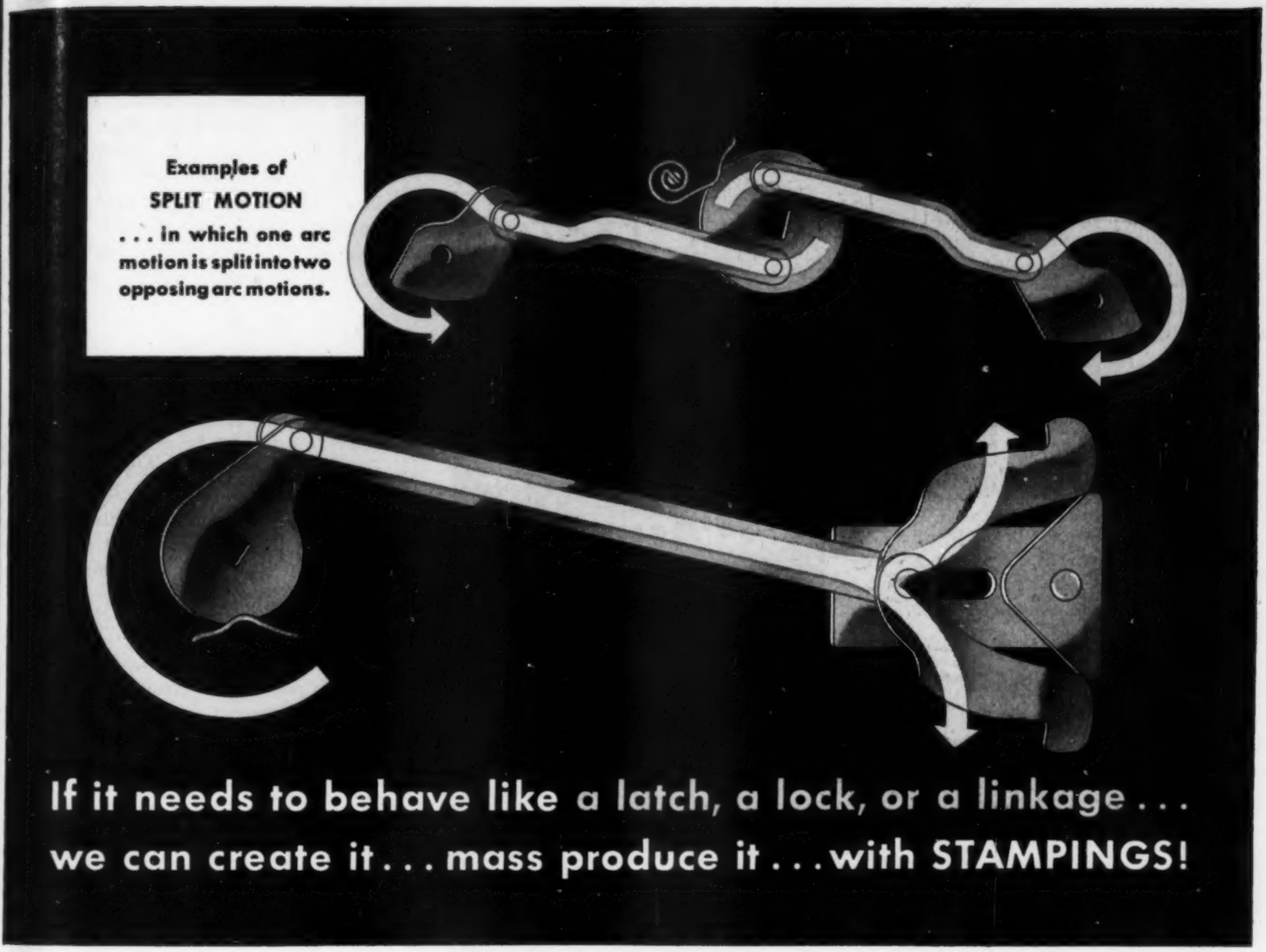
Wellman Engineering Co., Cleveland, O., manufacturer of steel mill equipment and machinery for handling heavy bulk materials, has acquired the property and business of the Anker-Holth Mfg. Co., Port Huron, Mich. The purchased company, which manufactures hydraulic and pneumatic cylinders, chucks, collets, air valves, and accessories, will operate as the Anker-Holth Division of the Wellman Engineering Co. with headquarters at Port Huron.

♦

Worthington Pump & Machinery Corp., Harrison, N. J., has acquired Wintroath Pumps Inc., Alhambra, Calif. Wintroath, manufacturer of vertical turbine well pumps, will operate as a wholly owned subsidiary of Worthington.

♦

Airborne Instruments Laboratory executives and employees in association with Laurance S. Rockefeller and certain of his associates, and with the American Research and Development Corp., Boston, Mass., have purchased the entire capital stock of the Laboratory from Aeronautical Radio Inc., Washington, D. C. Most members of the AIL group now sharing part ownership of the Laboratory



Our specialty is designing and producing sure-acting mechanical devices that initiate a force or motion, transmit it, control it or check it.

Furthermore, through the development of modern manufacturing techniques, we can build precision motion-devices *by stamping* . . . assemble them by welding or riveting . . . to keep the cost unusually low.

If the type of motion used in your product has formerly required "machining-accuracy", our mass-production stamping and assembly techniques may make big cost reductions possible. Our new booklet, "We Make Motions", explains our facilities further. We'll be glad to send you a copy upon request.

THE REID DIVISION OF *The Standard Products Co.*

THE MARK OF A SUPERIOR PRODUCT SP

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WE MAKE MOTIONS

have been with it since its organization five years ago. Many of them also comprised the group of scientists originally assembled in 1941 to combat enemy submarine warfare. Recent AIL projects have included assignment of personnel to the Far East, an evaluation for the Air Navigation Development Board, Washington, of the omni-range navigational system, and work on the Berlin Airlift.

♦

Townsend Co., New Brighton, Pa., and the Cherry Rivet Co., Los Angeles, Calif., have merged. The west coast plant will operate as a Townsend division. Townsend is a manufacturer of rivets and a wide variety of special nails, self-tapping screws, lock nuts, small parts and other cold headed items; Cherry specializes in blind fasteners.

♦

SKF Industries Inc., Philadelphia, Pa., is placing in production ball and roller bearings to be marketed in the United States and foreign countries under an additional trademark—"Hess-Bright." The new trademark comes from the Hess-Bright Mfg. Co., one of the nation's earliest producers of antifriction bearings, who became affiliated with SKF in 1916. The principal reason for adoption of the trademark is to clarify the nature of export operations under the anti-trust laws. The company will continue to manufacture and sell ball and roller bearings to the domestic trade under the SKF trademark.

♦

Arwood Precision Casting Corp., Brooklyn, N. Y., has opened a New England branch plant at Groton, Conn. By doubling the firm's production capacity, the new plant will eliminate the present production strain of ferrous alloy precision investment casting of aircraft and instrument parts as well as nonmilitary products.

♦

Dodge Mfg. Corp., Mishawaka, Ind., announces that its two subsidiaries, Chicago Thrift Co. and Etching Co. of America, have consolidated their operations in the plant of the former at 1555 North Sheffield Ave., Chicago, Ill. They have been legally merged under the name Chicago Thrift-Etching Corp.

♦

H. K. Porter Co. Inc. is spending $1,500,000 for the expansion of plant and manufacturing facilities of its subsidiary, Quaker Rubber Corp., Philadelphia, Pa. The expansion plan will increase the finished rubber

FOR THE BEST IN PRESSROOM EQUIPMENT...

DIAMOND Roller Chains

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In the printing industry also, leading machinery builders find Diamond Roller Chains expedite design and construction—and assure long-life reliable operation in service as well . . . The Christensen Varnishing Machine is a good example of modern pressroom equipment making effective use of Diamond Chains.

For the machines and equipment you build or use, you'll get dependability and long-life service with Diamond Roller Chains. For the latest data, write for New Catalog 709.

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Christensen Varnishing Machine Has These Diamond Drives

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Elevators
Bank Feeds
Fountain Rolls
Exhauster
Elevator front and rear operation
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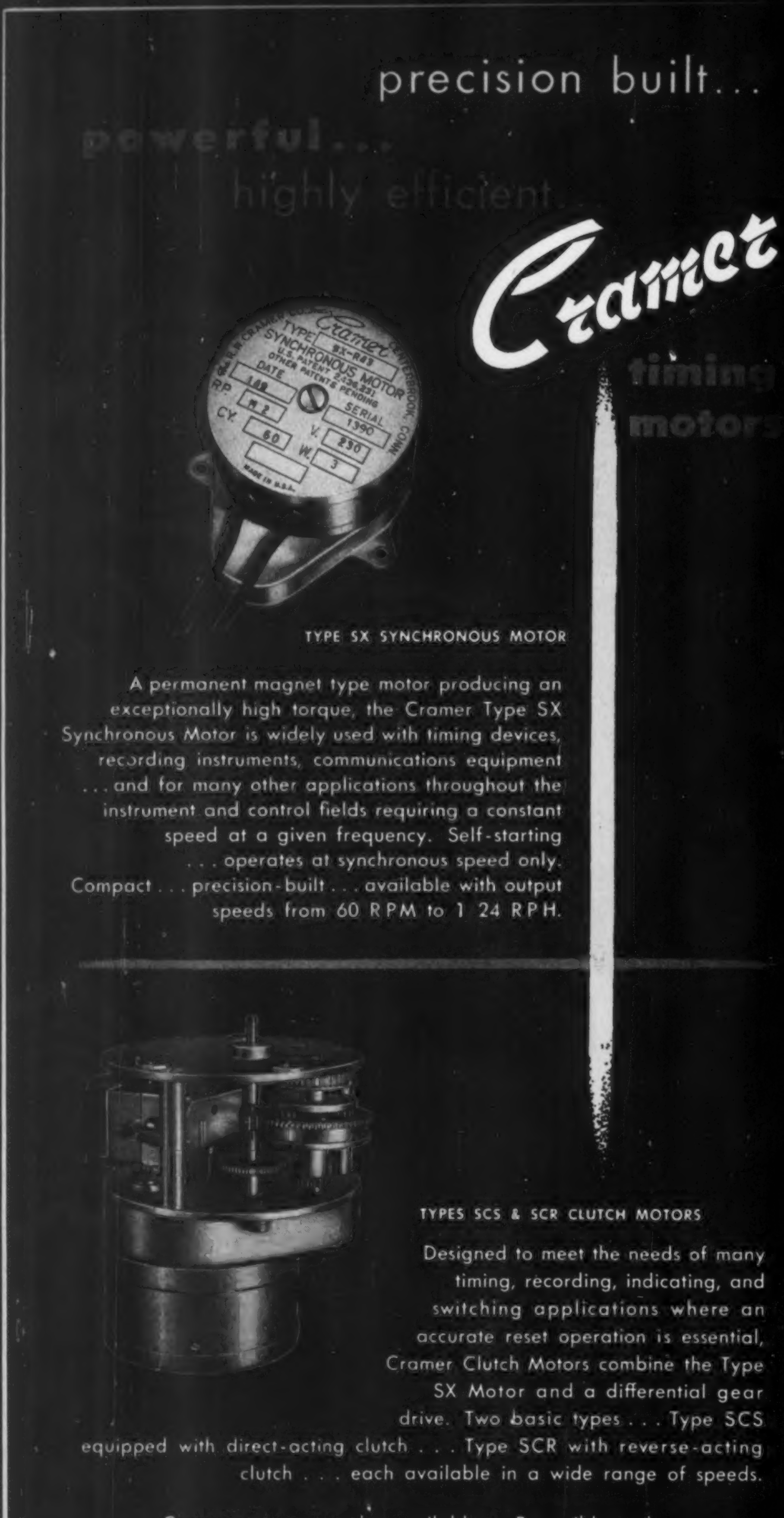
Grip Bars Operations

DIAMOND ROLLER CHAINS



products capacity of the plant approximately 30 per cent. Centered around a new compounding and mixing building, the expansion program includes a new administration building, and a new $300,000 72-inch, double-deck, conveyor belt press.

♦

Westinghouse Electric Corp. will open a plant for the manufacture of Micarta at Hampton, S. C. Scheduled to begin operation early in 1951, the plant will manufacture primarily decorative materials for homes, offices and stores. The laminated plastic is also used for bearings, propeller shafts, helmet liners, and other applications. The building housing the new plant was leased from the Plywoods-Plastic Corp. It contains 40,000 sq ft of floor space and is equipped with various types of plastics-processing machinery.

♦

Square D Co. has sold the business and assets comprising the Kollsman Instrument Division to the Kollsman Instrument Corp. The address will remain 80-08 45th Ave., Elmhurst, N. Y.

♦

Owens-Corning Fiberglas Corp. has completed arrangements for building a new Fiberglas yarn manufacturing plant in Anderson, S. C.

♦

Continuous Metalcast Corp. has been formed to take over the American and Canadian rights to the Junghans and Dunross continuous casting patents as well as other inventions, patents, engineering facilities and license agreements owned by Mr. Rossi, president of the new firm. Three metal companies share in the ownership of the new company with Mr. Rossi: **Allegheny Ludlum Steel Corp.**, which has been perfecting the process for continuously casting steel; **Scovill Mfg. Co.**, large user of the process for continuous casting of brass; and **American Metal Co. Ltd.**, now using the process for copper.

♦

B. F. Goodrich Co., Akron, O., will build a $2,500,000 plant for the manufacture of industrial rubber products on a 120-acre tract near Marion, O. The new plant will have more than 125,000 sq ft of floor space.

♦

United States Rubber Co. has purchased the Buna-N synthetic rubber plant of Esso Standard Oil Co. in Baton Rouge, La., as a major step in the expansion of its facilities for the manufacture of chemicals, plastics and synthetic rubbers. The plant will

be operated by the Naugatuck chemical division of the rubber company which will continue to market Buna-N rubber under the trade name Paracril. Present capacity of the plant is 15,000,000 pounds of Buna-N and high styrene latex annually; U. S. Rubber plans to expand production facilities to 30,000,000 pounds annually.

♦

Minneapolis-Honeywell Regulator Co. is expanding the industrial production and operating facilities of its Brown Instruments Division. The new expansion has been made possible by the purchase of the Thomas M. Royal plant, Philadelphia, Pa. The company has also acquired about 60,000 sq ft of undeveloped property adjacent to the new site. The building acquired is a three-story structure which was partially occupied by Honeywell on December 15. Complete possession is expected this month.

♦

Dow Chemical Co. has announced receipt of a deed from the General Services Administration, under the authorization of the Secretary of Defense, for the former Standard Steel Spring plant at Madison, Ill. The plant will be utilized for rolling and extruding magnesium for defense purposes. Present plans call for completion of installation and opening of production as soon as possible. The installation, to be completed as soon as possible, will include the first modern continuous rolling mill for magnesium. All previous magnesium rolling has been done on hand mills.

♦

Westinghouse Electric Corp. is planning two new East Pittsburgh buildings that will increase by 65 per cent the company's capacity to produce giant electric generators. This expansion, providing more than 300,000 additional sq ft, will make possible the construction of generators larger than 150,000 kw, 3600 rpm.

♦

Servo-Tek Products Co., Paterson, N. J., has completed construction of a new two-story addition to its plant, providing a 60 per cent increase in floor area. This added space will be used to improve and increase facilities for manufacturing of industrial and military electromechanical equipment.

♦

Alfred B. King Co. and its subsidiaries, Churchward Welding Accessories and KIF Industrial Fabricators, have completed a plant expansion and consolidation program. The com-

panies have moved to their new 10,000 sq ft plant in New Haven, Conn. Fabrication of special materials handling equipment and stainless steel items for meat packing, textile and general manufacturing industries has already begun in the plant; the company also fabricates steel and alloys to specifications.

♦

C. A. Norgren, Denver, Colo., manufacturer of pneumatic equipment, is observing its twenty-fifth anniversary by building a new plant. The new structure will be erected on a 3½-acre tract in Englewood, a suburb of Denver, and will provide more than twice the capacity of present facilities. Seven additions to the firm's present plant have exhausted expansion possibilities there and necessitated the new building project.

♦

Dow Chemical Co. has received a letter of intent from the United States government for the reopening of the government magnesium facilities at Velasco, Tex., for the production of magnesium from sea water. The necessary rehabilitation for operation of this plant is being conducted under government supervision. Partial production of magnesium is expected in early spring of this year. The Velasco plant, utilizing sea water as the raw material for magnesium production, is a government-owned plant and has been maintained in stand-by since the end of World War II.

♦

United States Radiator Corp. has announced that the recently acquired assets and business of Cyclotherm Corp., Buffalo, N. Y., will continue to operate as a special entity.

♦

Machinery Mfg. Co., former builders of the Vernon line of jig borers, millers, shapers, and tool and cutter grinders, has announced its reorganization under a new firm name. The new company is known as the **Diversified Metal Products Co.,** with manufacturing facilities located at 5125 Alcoa Ave., Los Angeles, Calif. At present, a development program is in process for precision machine tools. Trial runs of these tools are being carried out; full production is expected shortly.

♦

Standard-Thomson Corp., manufacturer of automotive and aviation parts, is planning a $1,500,000 expansion in the Dayton, O., area. The company is negotiating for the purchase of a 140-acre tract of land near the Dayton municipal airport at Vandalia, O., for the construction of

the new plant. Plans call for 180,000 to 200,000 sq ft of floor space. Officials of the corporation have said that the company has outgrown its present facilities at Dayton, but that it is probable all six of the Dayton plants will be maintained and will continue production.

Black & Decker Mfg. Co., manufacturer of portable electric tools, has purchased approximately 180 acres of land at Hamstead, Md. A branch plant will be erected on the site; construction is expected to begin in early spring. The company's Townson plant will continue production with transfer of some supervisory personnel only to Hamstead. The new building program was necessitated by lack of space for increasing facilities at Townson.

Corning Glass Works will commemorate its 100th aninversary this year. Some of Corning's outstanding achievements have been the first practical bulb for Edison's electric lamp, the development of Pyrex brand heat-resistant glass, the casting of the 200-inch telescope disk, and the mass production of glass for television picture tubes.

Flexible Tubing Corp. has moved from Branford to its new plant in Guilford, Conn. Costing more than $100,000 and containing over 15,000 sq ft of manufacturing space, the plant was built primarily to accommodate increased demand for Spiratube, a fluid tubing. The plant is located on a 23-acre plot; plans for further expansion have been worked out.

Buckeye Brass and Mfg. Co., Cleveland, O., manufacturer of bearing bronze, is observing its 50th anniversary. Aside from manufacturing standard sleeve type bronze bearings and machined bronze maintenance bars, the company has laboratory, metallurgical, pattern and machine facilities for the production of bearings conforming to desired metal analysis.

American Cladmetals Co., Carnegie, Pa., is expanding its production facilities to meet heavier demand for its Electroshield metal sheet, a clad metal of rolled copper bonded to a base sheet of magnetic low-carbon steel which serves to eliminate outside interference in communication systems such as radar, radio and television.

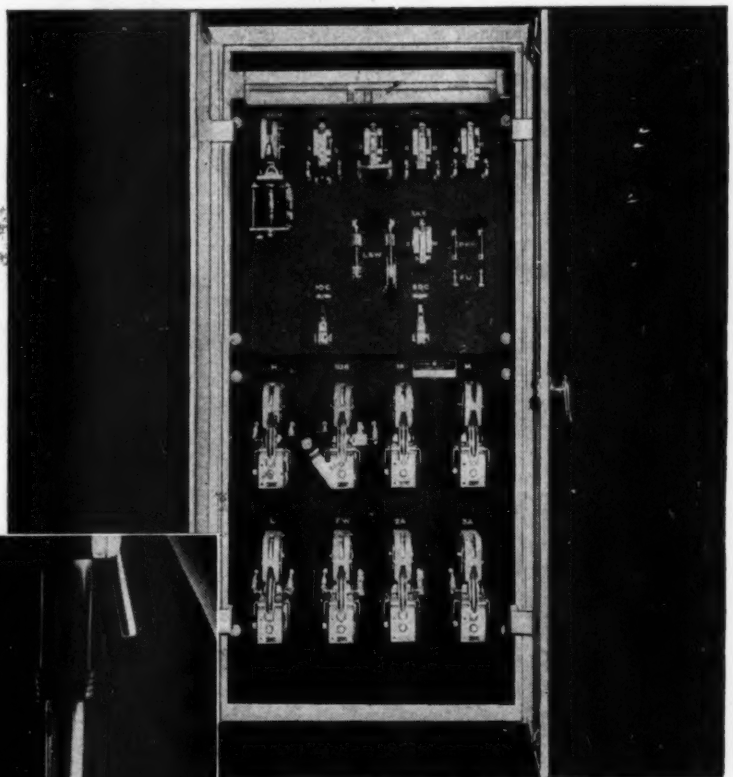
LAMINATES News

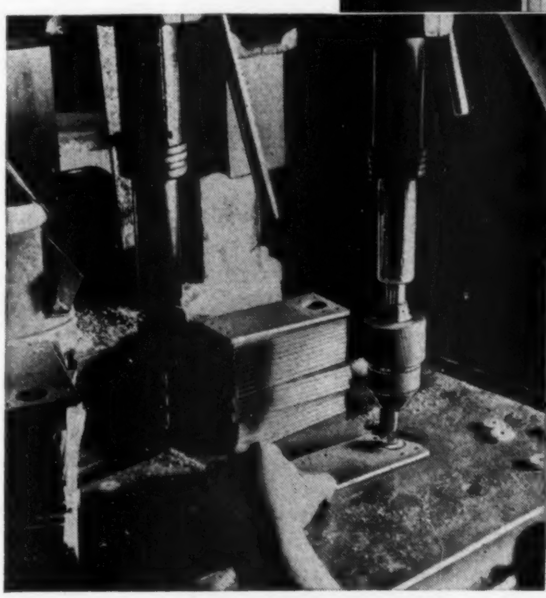
News of General Electric Plastics Laminates that can be of importance to your business.

G-E PLASTICS LAMINATES Give You EXTRA QUALITY AT LOW COST!

The engineering and manufacturing experience gained through many years in both the production and use of plastics laminates by General Electric is your assurance of extra quality at low cost.

For example, General Electric is one of the world's largest producers of naval and industrial control panels for both electrical and electronics applications. Through extensive work with this equipment, G.E. has developed a complete, high-quality line of laminated sheets for a wide variety of industrial and military applications.





FAST WORK!

With G-E Laminates, most high-speed machining operations are easily performed on standard wood and metal-working tools. Intricate shapes and fine cross sections can be machined to close tolerances with a minimum of rejects. Work can usually be performed dry, for easier handling of finished pieces.

COMPLETE LINE OF LAMINATES

General Electric produces a complete line of plastics laminates including sheets, tubes, and rods with cloth, paper, glass fabric, or special bases for a wide variety of applications. For more information about G-E Plastics Laminates, write to Section Y-1, Chemical Department, General Electric Company, Pittsfield, Mass.

● Also look to General Electric for silicone insulation, insulating varnishes, sealing and filling compounds, mica insulation, varnished cloth and tape.

DEPENDABILITY THROUGH EXPERIENCE

Sheets . . . . Tubes . . . . Rods . . . . Insulating Materials

You can put your confidence in

GENERAL ELECTRIC

SOCIETY ACTIVITIES

IN answer to a request made by Robert L. Clark, director of the Manpower Office of the National Security Resources Board, the Engineering Manpower Commission of the **Engineers Joint Council** has proposed the establishment of a National Engineering Personnel Board to make selections for military, civil defense or industrial allocation from a reserve of men with training in one of the critical fields of engineering. The EMC has asked that the reserve be created through the registration by selective service of every man, up to the age of 70, who has a bachelor's degree with a major in one of the critical fields or who is enrolled in a program of training leading to a bachelor's degree or higher in one of these fields, or who is employed in one of these fields. The EMC has recommended the setting up of a National Engineering Personnel Board "whose duties shall be to review registrants, to establish criteria for inclusion in a reserve, to classify the registrants, and to make selections with critical skills for military, civil defense and industrial allocation. This Board shall advise the President as to critical needs, allocations, etc., and shall administer the reserve. Regional boards shall be appointed as directed." The 20-member EMC which has made these recommendations is composed of representatives of the member societies of the Engineers Joint Council—the five founder engineering societies, the **American Society of Mechanical Engineers, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Institute of Electrical Engineers, American Institute of Chemical Engineers**—plus members from the **American Society for Engineering Education.** E. G. Bailey, vice president of the Babcock & Wilcox Co., is the temporary chairman.

•

Dale Roeder, executive engineer, commercial vehicles, Ford Motor Co., has been elected president of the **Society of Automotive Engineers** for 1951. James Hale of Firestone, who had been the nominee for the office, died recently of a heart attack. Roeder was beginning the second year of his two-year term as SAE coun-

Anchor Ductile Sleeve Couplings assembled on two wire braid hose for high pressures.

Anchor Sleeveless Couplings assembled on either single wire braid hose or two rayon braid hose for medium or low pressures.

Anchor Clamp-type Couplings are ideal for field service use and emergency repairs. Easy to put on and take off—withstand high pressures.

Use Anchor Assembled Hose Units with the outstanding fittings shown above. You'll have less trouble in the shop on assembly — and less trouble in the field on the job.

ANCHOR COUPLING CO. INC.

Factory: Libertyville, Illinois • Branch: Detroit, Michigan

Time is money. And whenever you save time, you reduce costs.

That's why it pays to use Anchor Adapter Unions and Related Fittings. You see, they're designed especially to speed the attachment of Anchor hydraulic hose assemblies to equipment of all kinds.

In addition to cutting assembly costs, Anchor Adapter Unions and Fittings have these important advantages:

- They provide a leakproof ground-joint connection.
- They are small in size, require little space, and provide a neat appearance.
- You can connect and disconnect them many times without destroying the seal.
- Made from solid steel bar stock and plated to prevent rust, they stand up under the toughest service conditions.
- Their use lets you eliminate one or more pipe-thread joints—gives you a better piping job.
- Assembly in confined spaces is quicker and easier.

The Anchor line of Adapter Unions and Related Fittings is the most complete line available. Save yourself time and money—select those that fill your specific needs.

Send for complete information on Anchor Adapter Unions and Fittings

TEAR OUT THIS COUPON AND MAIL TODAY!

ANCHOR COUPLING CO. INC.
Dept. MD-21, Libertyville, Illinois

I like the dependability, the safety, and the time-and-money saving features of Anchor Adapter Unions and Fittings. Please send me a catalog.

Name.. Position........................

Company..

Company Address..

City.. (....) State........................

D-4

cilor at the time of his election to the presidency. L. Ray Buckendale, vice president of engineering, Timken-Detroit Axle Co., has been elected to fill Roeder's unexpired 1950-51 term as councilor.

♦

Sixteen chapters of the **American Materials Handling Society** will participate directly in the program planned for the Materials Handling Conference which will be held concurrently with the Materials Handling Exposition at the International Amphitheatre, Chicago, Ill., April 30 to May 4 inclusive. The society is sponsoring the conference and the Material Handling Institute is sponsoring the exposition. Clapp & Poliak Inc., New York, will conduct the exposition. General chairman of the conference will be A. K. Strong, marine division, Columbia Rope Co. Serving with him on the executive committee will be Donald W. Pennock, factory engineer, Carrier Corp., who is the society president, and Irving M. Footlik, materials handling consultant, society treasurer.

♦

Election of four educational institutions to active membership in the Engineering College Research Council of the **American Society for Engineering Education** was announced by Dr. Gerald A. Rosselot, chairman of the council and director of the Georgia Tech Engineering Experiment Station. The four colleges are: California Institute of Technology, Pasadena; Dartmouth College (Thayer School of Engineering), Hanover, N. H.; Montana State College, Bozeman; and the University of Toledo, Toledo, O. Extensive activity in engineering research supplementing an effective program of undergraduate engineering education is required for election to the Research Council. These last elections bring to 88 the number of institutions active in the organization.

♦

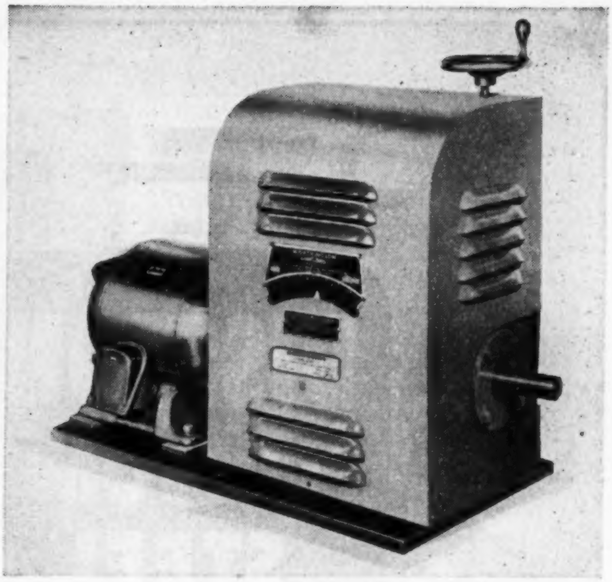
John G. Bucuss, general manager, strapping division, Acme Steel Co., was elected president of the **Materials Handling Institute** for 1951 at the annual meeting in New York City.

♦

The year 1951 marks the fiftieth anniversary of the National Bureau of Standards. A large number of the principal scientific and technical organizations of the nation, in recognition of the role of the Bureau in science, have planned meetings in Washington in 1951 in honor of the semicentennial.

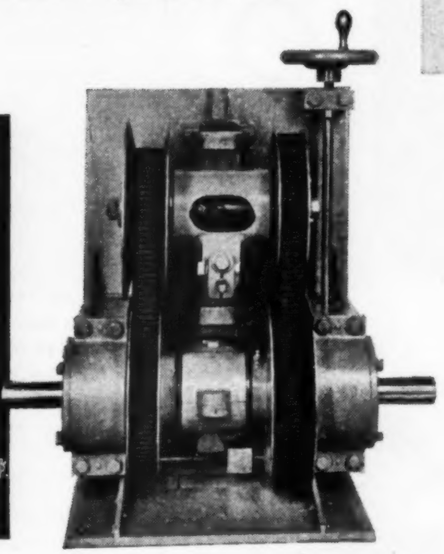
BUILD IN INSTANTANEOUS SPEED CONTROL
with the
New Variable Speed Drive

that uses two belts to vary speed and reduce belt replacement



2 NARROW BELTS . . . INSTEAD OF 1 WIDE BELT

gives smoothest operation . . . highest ratios in smallest space . . . longest belt life



1-15 HP, MAX. RATIO 16-1					
Model	Ratio	Minimum RPM Output Shaft	HP	Maximum RPM Output Shaft	HP
A	16-1	215	¼	3450	1
B	10-1	300	1	3000	3
C	9-1	400	1½	3600	5
D	8-1	360	2½	2880	7½
E	6-1	410	4	2460	10
F	6-1	370	5½	2220	15

All models available in plain units and Monobloc (built-in motor). Skeleton models if desired. Available with hand-screw control or no control (to be adapted to your requirements).

The tandem belt design is a feature of
WORTHINGTON ALLSPEED DRIVES

Here is a new, enlarged line of instantaneous step-less variable speed drives . . . with important exclusives you'll want to investigate for your machinery.

Worthington ALLSPEED DRIVES are now built in six sizes—from 1 to 15 hp—around the tandem-belt design which gives a *greater range* of speed variations and greatly reduces belt replacement.

THE NARROWER—THE BETTER

This tandem-belt design permits using a *narrower belt* than most variable speed drives. Obviously: the narrower belt suffers less from side compression—lasts longer. And belt replacement, when necessary, is made easily—no dismantling of the complete unit—and costs less, too.

Another important Worthington feature—motor-equipped units have standard NEMA frame 1750 rpm motors—a convenience in emergencies.

Still other important features: automatic positive belt tensioning . . . all rotating parts fully machined and balanced and carried in shielded, life-lubricated ball bearings . . . in-line input and output shafts . . . mountable in any position, to run in either direction.

Send coupon for Worthington Allspeed Drive bulletins AS-1600-B3 (A drive) and AS-1600-B4 (C drive). Worthington Pump and Machinery Corporation, Worthington Allspeed Drive Sales Division, Holyoke, Mass.

WORTHINGTON

THE GOOD RIGHT HAND OF INDUSTRY

POWER TRANSMISSION: sheaves, V-belts, variable speed drives
PUMPS: centrifugal, power, rotary, steam
AIR COMPRESSORS: water-cooled, air-cooled

Worthington Pump and Machinery Corporation
Worthington Allspeed Drive Division
Holyoke, Mass.

Please send bulletins AS-1600-B3 and AS-1600-B4 on Worthington Allspeed Drive.

Name................................

Company................................

Address................................

SALES AND SERVICE PERSONNEL

THE APPOINTMENT of **L. W. Jander** to the post of sales manager of the industrial division of Henry Disston & Sons Inc. was announced recently. Mr. Jander, a veteran of sixteen years with the company, succeeds **J. F. Wilkinson,** who has resigned to enter his own industrial distributing business in Miami, Fla.

♦

Mark K. Howlett, of the chemical department of General Electric Co., has been appointed silicone sales supervisor with headquarters at Waterford, N. Y. He will have direct responsibility for selecting, organizing and directing the silicone field sales organization.

♦

Succeeding **Ralph M. Neumann,** who has retired because of ill health, **Robert G. Kenly** was recently appointed general sales manager of the New Jersey Zinc Co. and the New Jersey Zinc Sales Co.

♦

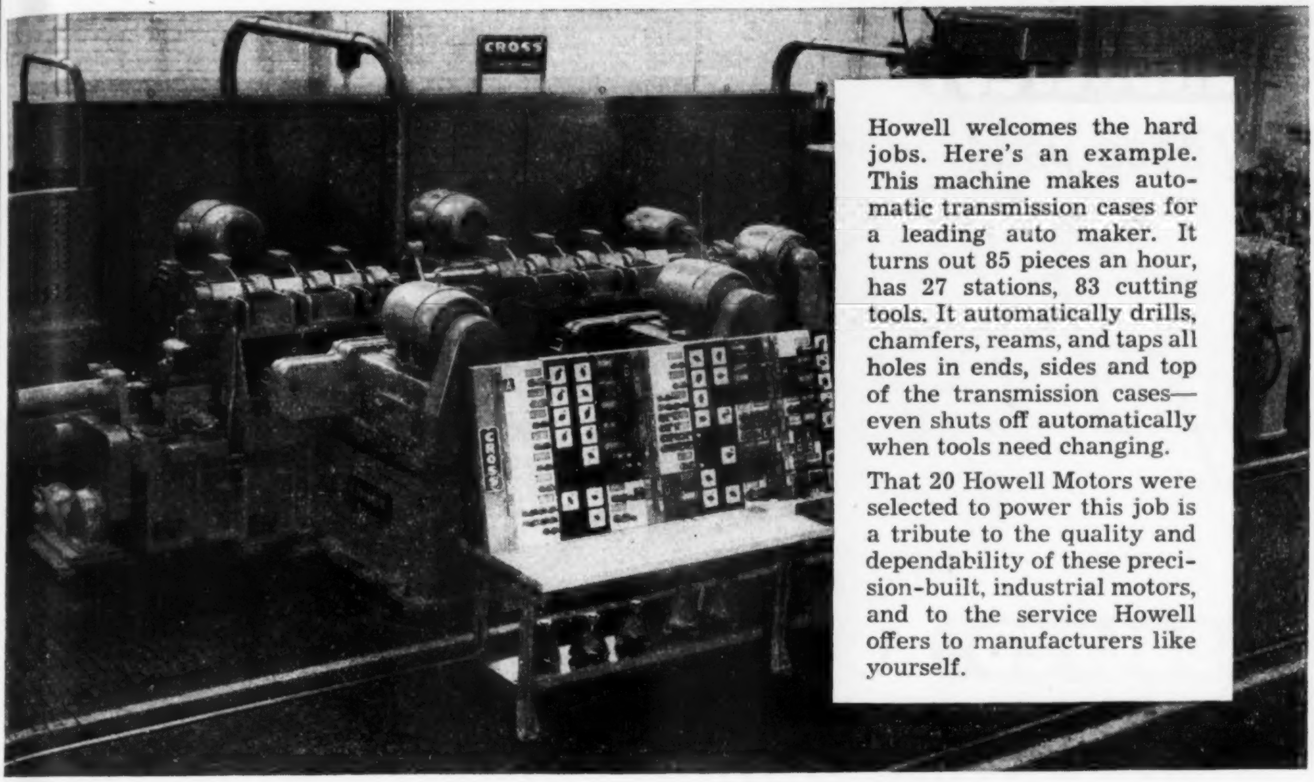
The Cambridge Wire Cloth Co., Cambridge, Md., recently announced the appointment of **Irwin F. Pink** as executive vice president and **Edward N. Evans** as general manager. Having joined the company in 1920, Mr. Pink has served as general manager since 1942. Mr. Evans joined the company in 1937 and in 1940 was made sales manager for woven wire conveyor belts, industrial wire cloth, woven wire slings and special metal fabricatons. He was later made secretary-treasurer, retaining this position until his present appointment.

♦

To better aid customers in the Chicago area to solve chain drive problems, the Atlas Chain and Mfg. Co., Philadelphia, has appointed **D. A. Paisley** as technical sales representative. He will make his headquarters in the company's office at 570 Randolph St., Chicago, Ill.

♦

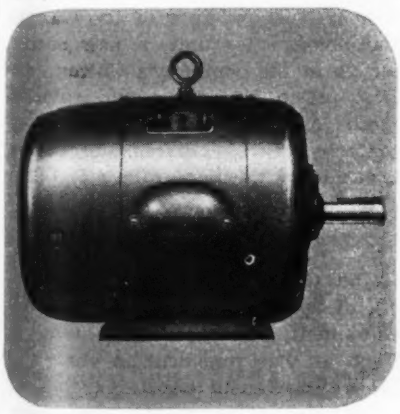
The appointment of **Donald M. McGrath** as general manager of the Red Bank division of Bendix Aviation Corp. at Red Bank, N. J., was announced recently. Formerly assistant director of sales and service for the Eclipse-Pioneer division of Ben-



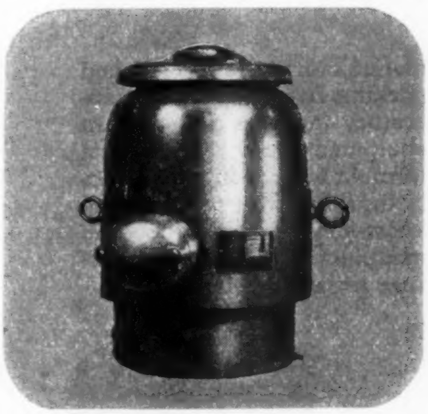
Howell welcomes the hard jobs. Here's an example. This machine makes automatic transmission cases for a leading auto maker. It turns out 85 pieces an hour, has 27 stations, 83 cutting tools. It automatically drills, chamfers, reams, and taps all holes in ends, sides and top of the transmission cases—even shuts off automatically when tools need changing.

That 20 Howell Motors were selected to power this job is a tribute to the quality and dependability of these precision-built, industrial motors, and to the service Howell offers to manufacturers like yourself.

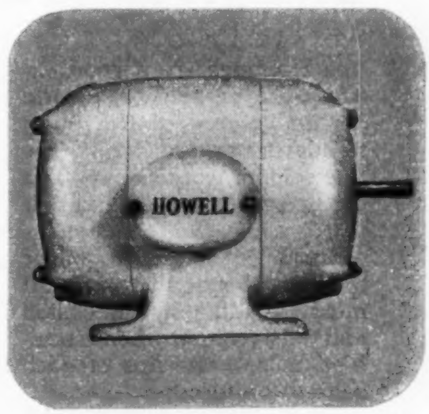
Solution for . . .
THE CASE OF AN AUTOMATIC TRANSMISSION



Howell Type K Motor. Offers constant performance in the presence of dirt, dust, fumes, and moisture. Sizes from 3 to 150 H.P. at 1800 R.P.M. Either vertical or horizontal mounting.



Howell makes specially designed motors—vertical, round body, flange and face mounting, built-in stator and rotor jobs, etc.—to meet a wide range of requirements.



Howell Sanitary Motors meet the most exacting standards of the dairy and food industries. They contain no pockets, cracks, or crevices. Available for vertical or horizontal mounting.

Read this if you need special motors

Howell offers a unique job-engineering service for special motor applications.

With it, you get: (1) cooperation of our engineering personnel; (2) prompt quotations on both standard and custom motors; and (3) the ability to accurately manufacture custom-designed motors within reasonable time.

We believe these services will save you, as a purchaser of electric motors, valuable time and money.

May we apply our facilities and engineering ability to your problem?

HOWELL MOTORS

HOWELL ELECTRIC MOTORS CO., HOWELL, MICH.

Precision-built Industrial Motors Since 1915

HOWELL Red Band MOTORS

dix at Teterboro, N. J., he succeeds **W. W. Fisher,** who has been named general manager of a newly created division at Davenport, Iowa.

♦

C. Carlisle Tippit, manager of the order and planning department of the Reliance Electric & Engineering Co. since January, 1948, has been appointed general purchasing agent of the firm, and **Walter H. Behnke,** a member of the company's applied engineering department since 1945, has assumed Mr. Tippit's former duties. In his new position, Mr. Behnke will administer sales planning and be responsible for the order-pricing and sales-service functions of the home office.

♦

Formerly affiliated with the International Harvester Motor Truck division at Springfield, O., and more recently with Hupp Corp. at Cleveland, **Charles W. Howard** has joined the rim sales staff of the Goodyear Tire & Rubber Co. as a field contact man.

♦

George A. Wampler, former sales representative in the Allis-Chalmers Mfg. Co. Memphis district office, has been named manager of the Chicago warehouse sales unit, a new section set up in the company's Chicago district office to handle the sales of small apparatus including motors, controls, Texrope drives and pumps. Location of the new unit is 500 East 27th St. in Chicago.

♦

The Conoflow Corp., manufacturers of valves and pneumatic control equipment, has appointed **John C. Koch** as vice president in charge of sales. Previously associated with one of the major instrument companies, Mr. Koch has been active in sales engineering work in the industrial control field for many years. He joined Conoflow in 1945 and has been acting in the capacity of general sales manager in Philadelphia.

♦

E. O. Clark has recently been advanced to industrial products sales manager for Vickers Inc., and has moved to Detroit to assume these new duties. For the last ten years, Mr. Clark has been district manager with offices in Worcester, Mass., and has been with the Vickers organization in other capacities in the sales and engineering divisions for a total of fifteen years. **J. C. Carpenter** succeeds Mr. Clark as the Worcester, Mass., district manager. Vickers Inc.

also recently announced the appointment of **M. J. Taup,** formerly district manager in Chicago, as mobile products sales manager with offices in Detroit. **A. M. Lane** and **M. T. Gray** have assumed Mr. Taup's former duties.

♦

In line with an expansion program, **Arthur E. Raabe** has been named general manager of the Eclipse-Pioneer division of Bendix Aviation Corp., Teterboro, N. J. **Raymond P. Lansing,** Bendix vice president and group executive in charge of Eclipse-Pioneer, the Scintilla-Magneto division at Sidney, N. Y., the Red Bank division at Red Bank, N. J., and the Friez Instrument division at Baltimore, has been, in addition, general manager of Eclipse-Pioneer. All of these divisions are now being called upon to meet increasing military demands for their products, and with the appointment of Mr. Raabe, Mr. Lansing will devote his full attention to the expansion of their operations.

♦

John D. Dickinson, formerly manager of locomotive sales of Lima-Hamilton Corp., at New York, has been appointed assistant district manager of the New York district office of Baldwin-Lima-Hamilton Corp. Mr. Dickinson is well known in the locomotive field, having been associated with Lima-Hamilton since 1927.

♦

Manager of the company's Syracuse, N. Y., office since 1946, **N. W. Landis** has been named manager of the Detroit district office of Allis-Chalmers Mfg. Co. He succeeds **F. S. Schuyler,** who is retiring after forty-three years of service. **A. J. Mestler Jr.,** a sales representative in the New York district office since 1948, replaces Mr. Landis as manager at Syracuse.

♦

L. A. Watts has been appointed assistant general sales manager of the Wickwire Spencer Steel division of the Colorado Fuel and Iron Corp. In 1938, Mr. Watts joined the then Wickwire Spencer Steel Co. as a chemist in the Buffalo plant. Since that date he has held numerous positions, among them being foreman, assistant superintendent and metallurgist in the Buffalo wire mill, manager of the general wire sales department, and manager of the Detroit district sales office. In 1949 he established and managed the pig iron and semifinished sales department. In addition to his new duties, Mr. Watts will continue to supervise and

direct the pig iron and semifinished sales department. He will be located in the corporation's executive offices at 500 Fifth Ave., New York 18, N. Y. Succeeding Mr. Watts as sales manager of the wire products department of the Wickwire Spencer Steel division is **Robert M. Wagner,** who has served in various capacities in the Chicago district sales office and in the general wire sales office located in Buffalo, N. Y. His most recent position was that of assistant wire sales manager.

•

Charles H. Besly & Co., Chicago manufacturers of abrasive wheels, grinders, taps and reamers, recently announced the election of **Norman C. Minehart** as vice president in charge of the company's abrasive division and the appointment of **Jack T. LeBeau** as manager of the abrasive department. Both men will make their headquarters at Besly's general office at 118 North Clinton St., Chicago, Ill.

•

Almon O. Snyder, 8001 Carnegie Ave., Cleveland, O, has been appointed factory representative for Ohio, Pennsylvania, West Virginia, Kentucky and southern Indiana by the Hose Accessories Co.

•

Two new representatives were recently appointed by the Barry Corp., Watertown, Mass. They are **Ron Merritt,** 217 Ninth Ave., North Seattle 9, Wash., and **Seymour Sterling,** Sterling Sales Corp., 13331 Linwood Ave., Detroit, Mich., to handle Barry equipment for shock and vibration control in the Pacific northwest and the state of Michigan, respectively.

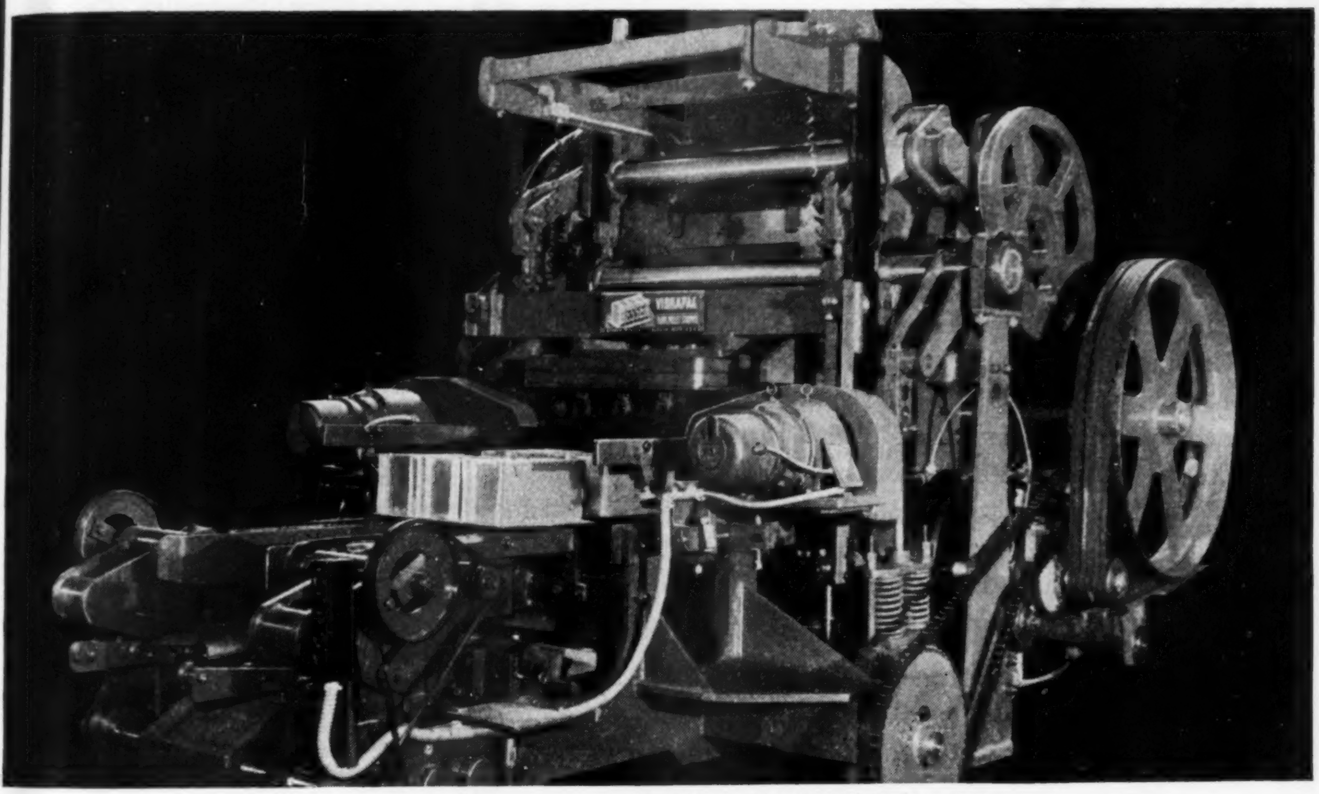
•

In order to assure prompt service to jobbers, the personnel of the jobber division of Clarostat Mfg. Co. Inc., has been expanded with the addition of **Jim F. Smith,** who recently joined the division headquarters staff.

•

The Whiton Machine Co., New London, Conn., has announced the appointment of **Evan Price** as turbine sales manager. Formerly in charge of turbine sales for the Kissick Co. of New York, Mr. Price has an extensive technical and practical background of turbine sales experience in the power plant and oil refinery fields. He will make his headquarters in the New London offices of the Whiton Machine Co.

"ICB" Units Measurably Improve Production of Building Block On Besser Vibrapac



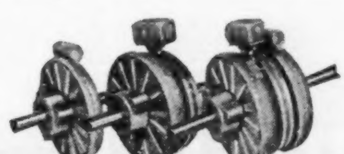
A new Besser Vibrapac equipped with a Warner "ICB" Clutch Brake unit on jack-shaft to engage and disengage machine flywheel and main drive motor.

What Besser says About the WARNER "ICB" Unit

Formerly the Vibrapac was controlled by starting and stopping the main drive motor. Then, different lengths of time were required to feed varying grade materials. This reduced over-all productivity.

Now, a WARNER "ICB" Unit on the jack-shaft keeps the main motor and flywheel operating continuously. Machine can be started and stopped with cycles varying according to the feed rate of material. The result is greater production without taxing motor.

Warner "ICB" Units are electrically-powered, low-wattage clutches and brakes. They can be operated singly or in combination — automatically or by push-button control. Being electric, they give lightning-fast response. Compact and simple, they provide easy installation and long-term dependable operation. They're a new answer to a wide variety of old machine design and operation problems. For further information on how Warner "ICB" Units may help you — write today to the WARNER ELECTRIC BRAKE & CLUTCH Co., Dept. MD, Beloit, Wisconsin.



WARNER

ICB UNIT

Warner ICB Units are manufactured by Warner Electric Brake & Clutch Co. — pioneers in the field of electric brake design and application since 1927.

SALES NOTES

RECENTLY ANNOUNCED by the **Trabon Engineering Corp.**, Cleveland, was the appointment of the **Ritter Engineering Co.**, 3031 West Liberty Ave., Pittsburgh 16, Pa., as exclusive distributor in the Pittsburgh district for Trabon centralized lubrication systems. The new distributor will devote full time and effort to the design, sale, installation and servicing of Trabon oil and grease systems on all types of industrial machines.

•

National Motor Bearing Co. Inc. has announced the new location of their Detroit office at 726 Lothrop Ave., Detroit 2, Mich.

•

The completion of molds and service stocks of **AF 934** O-rings in all of the 101 new sizes recently added to the specification has been announced by the **Parker Appliance Co.** of Cleveland. The new additions bring to 189 the number of sizes now covered as AF 934 standard stock items by the company. These O-rings comply fully with the critical fuel-resistant service requirements of MIL-P-5315, being molded of a special compound especially suited to either static or dynamic service in sealing aviation or jet fuel systems and auxiliaries.

•

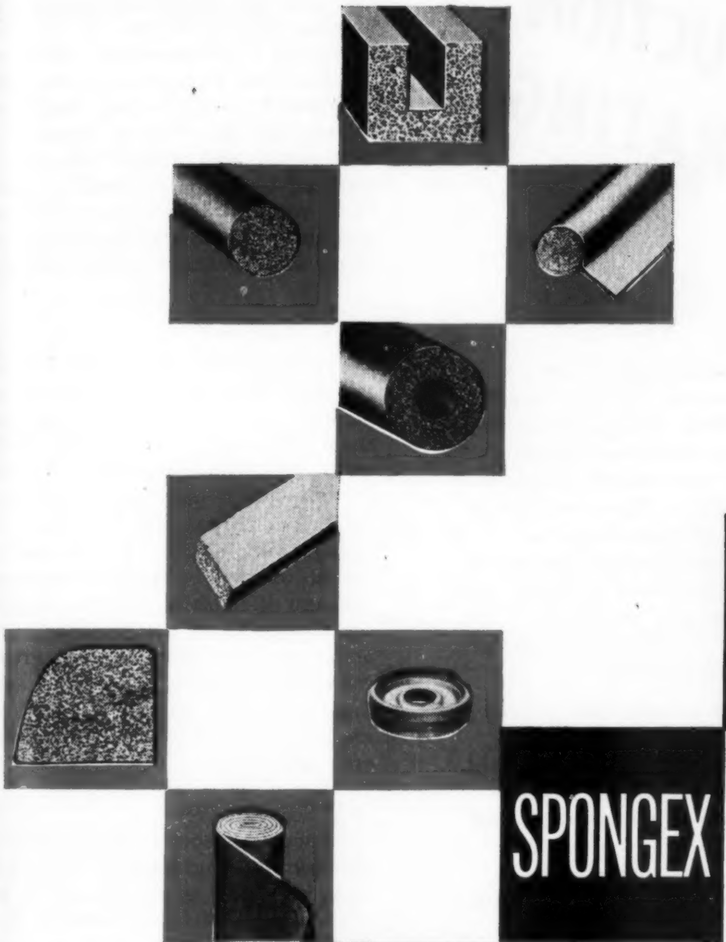
Because of increased demand by Baltimore's industrial firms for corrosion resisting metals, the Baltimore metal warehouse of **Whitehead Metal Products Co. Inc.** has been moved to enlarged and improved quarters at 4300 East Monument St., Baltimore, Md. John W. Marple will continue to direct activities as resident branch manager.

•

Flexitallic Gasket Co., Camden, N. J., has announced the addition of three new distributors and two new agents to its field organization. The new distributors are as follows: **Tate Engineering & Supply Co. Inc.,** Baltimore, Md., serving Maryland and Washington, D. C.; **A. L. Crump & Co.,** Chicago, serving northern Indiana and Illinois. **Carl Grimes & Co.,** Des Moines, Iowa, is a new agent in western Iowa, **Frank Valetti & Co.,** Philadelphia, a new agent, will

Here we are again...

Radio people turned radar specialists . . . washing machine makers now making fire control devices . . . and the rest of us doing what has to be done — we're in the same boat.



we have converted to fill your needs for

SPONGEX

cellular rubber

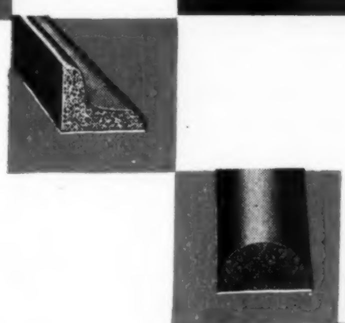
For insulation against the transmission of shock, sound, vibration and the passage of dust, air, temperature and moisture.

SPONGEX

*cell-tite**

Closed cell rubber, hard or soft. For insulation, flotation, space filling and sandwich construction.

*Spongex and Cell-Tite are our registered Trade Names



Sheets,
cord and strip;
die-cut shapes and
custom molded forms.

SPONGEX

silicone

The cellular rubber that works at extremes of temperatures as high as 500° F or as low as –130° F.

PARTICIPATING IN THE MANAGEMENT AND FINANCING OF KENTUCKY SYNTHETIC RUBBER CORPORATION

The World's Largest Specialists in Cellular Rubber

THE SPONGE RUBBER PRODUCTS COMPANY

400 DERBY PLACE, SHELTON, CONN.

serve the marine industry within the limits of Philadelphia, and **Southern Marine Supply Co. Inc.,** Savannah, Ga., is a new distributor serving the marine industry within the limits of Savannah. **Transmission Engineering Co.,** San Francisco, a Flexitallic distributor, is expanding its service to include the marine industry in that area, and **Eagle Asbestos & Packing Co.,** New Orleans, a distributor, will now serve both industrial and marine industries in eastern Louisiana and southern Mississippi.

•

Synthane Corp., Oaks, Pa., laminator and fabricator of thermosetting plastics for industry, has announced the removal of its New York district office from 233 Broadway, New York City, to larger quarters at 125 Parkway Rd., Bronxville, N. Y. This change, duplicating the recent removal of the company's downtown Chicago sales office to suburban Morton Grove, Ill., is designed to provide better parking facilities and greater convenience for customers and salesmen. The New York sales staff covers New York, New Jersey and southern Connecticut.

•

Announced recently by the **Reliance Electric & Engineering Co.,** Cleveland, was the establishment of new branch sales offices in Newark, N. J., and El Dorado, Ark., and the transfer from Syracuse to Buffalo of the district office directing the company's sales throughout northern and western New York State.

•

Veeder-Root Inc., Hartford, Conn., manufacturer of counting and computing devices, has opened a direct factory branch in New York City by taking over the office formerly occupied by its distributor, J. T. Quinlan Co., at 1775 Broadway, near Columbus Circle. Textile counters, which were not handled by the Quinlan firm, will now be sold and serviced out of this office, as well as the company's line of general industrial counters for mechanical and electrical operation. Mr. Quinlan will remain with Veeder-Root in an advisory capacity.

•

The opening of new branch offices at Denver, Colo. and Houston, Tex., was announced by the **Howe Scale Co.,** Rutland, Vt. The Denver office, located at 2524 Walnut St., is managed by Daniel O. Ferris, and the Houston office, 2215 McKinney Ave., is managed by Henry K. Leonard.

MEETINGS AND EXPOSITIONS

Feb. 18-22—

American Institute of Mining and Metallurgical Engineers. Annual meeting to be held at the Jefferson Hotel, St. Louis, Mo. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

Feb. 28-Mar. 2—

Society of the Plastics Industry. Sixth annual technical session of the Reinforced Plastics Division to be held at the Edgewater Beach Hotel, Chicago, Ill. W. T. Cruse, 295 Madison Ave., New York 17, N. Y., is executive vice president.

Mar. 5-9—

American Society for Testing Materials. Spring meeting to be held at the Netherland-Plaza Hotel, Cincinnati, Ohio. Additional information may be obtained from society headquarters, 1916 Race St., Philadelphia 3, Pa.

March 6-8—

Society of Automotive Engineers. Passenger car, body and materials meeting to be held at the Book-Cadillac Hotel, Detroit, Mich. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Mar. 15-17—

American Society of Tool Engineers. Annual meeting to be held at the Hotel New Yorker, New York, N. Y. Additional information may be obtained from society headquarters, 1666 Penobscot Bldg., Detroit 26, Mich.

Mar. 16—

Institute of the Aeronautical Sciences. Sixth annual flight propulsion meeting to be held at the Hotel Carter, Cleveland, Ohio. R. R. Dexter, 2 East 64th St., New York 21, N. Y., is secretary.

Mar. 19-23—

American Society for Metals. Western metal congress and exposition to be held in the Civic Auditorium, Oakland, Calif. William H. Eisenman, 7301 Euclid Ave., Cleveland 3, Ohio, is national secretary.

Apr. 2-5—

American Society of Mechanical

Seamless brass tube—having end spun—

constitutes this percussion primer tube blank

Percussion primer tube-body blanks can be produced in a jiffy here at Wolverine by the well-known Spun End Process*, which is used to form the end.

These fabricated blanks can be furnished by us to prime contractors who then just need to drill or punch the holes along the length of the tube, face to length, and ream and tap.

We are equipped to fabricate these blanks of other metal besides brass.

We invite prime contractors to give consideration to the many advantages presented by this fast, efficient, accurate process used for forming products of this type out of Wolverine seamless tube.

Our Customer Engineering Service will be glad to give you any assistance you may require in setting up the production of essential parts requiring ends that must be entirely or partially closed.

**a patented process RE: 22465*

WOLVERINE TUBE DIVISION
Calumet & Hecla Consolidated Copper Company
INCORPORATED
Manufacturers of seamless non-ferrous tubing
1433 CENTRAL AVENUE • DETROIT 9, MICHIGAN

PLANTS IN DETROIT AND DECATUR, ALA.
Sales Offices in Principal Cities

Engineers. Spring meeting to be held at Hotel Atlanta-Biltmore, Atlanta, Ga. C. E. Davies, 29 West 39th St., New York 17, N. Y., is secretary.

Apr. 4-6—

Midwest Power Conference sponsored by the Illinois Institute of Technology to be held at the Sherman Hotel, Chicago, Ill. Additional information may be obtained from Dr. R. A. Budenholzer, Director of the Conference, 3300 South Dearborn St., Chicago 16, Ill.

Apr. 16—

Packaging Machinery Manufacturers Institute. Semi-annual meeting to be held at the Hotel Dennis, Atlantic City, N. J. Additional information may be obtained from society headquarters, 342 Madison Ave., New York 17, N. Y.

April 16-18—

Society of Automotive Engineers. Aeronautic and aircraft engine display meeting to be held at the Statler Hotel, New York. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Apr. 16-18—

American Society of Lubrication Engineers. National convention to be held at the Bellevue-Stratford Hotel, Philadelphia, Pa. W. F. Leonard, 343 South Dearborn St., Chicago 4, Ill., is secretary.

Apr. 17-20—

American Management Association. The 20th national packaging exposition to be held in the Atlantic City Auditorium, Atlantic City, N. J. Additional information may be obtained from society headquarters, 330 West 42nd St., New York 18, N. Y.

Apr. 25-26—

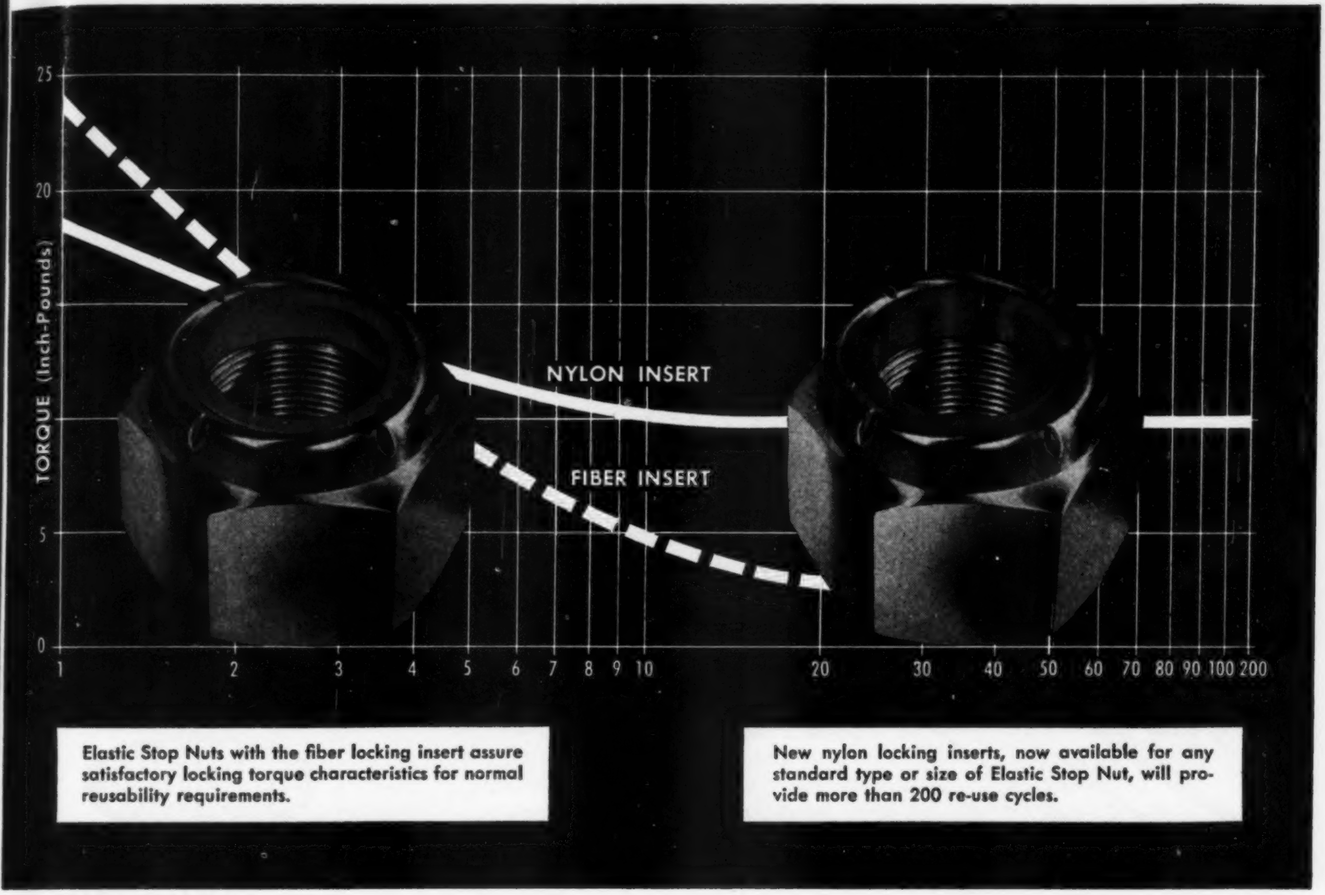
Metal Powder Association. Seventh annual meeting to be held at Hotel Cleveland, Cleveland, Ohio. Additional information may be obtained from society headquarters, 420 Lexington Ave., New York 17, N. Y.

Apr. 30-May 4—

Materials Handling Exposition to be held in the International Amphitheatre, Chicago, Ill. Additional information may be obtained from Clapp and Poliak, Inc., 341 Madison Ave., New York 17, N. Y.

Apr. 30-May 11—

British Industries Fair to be held at Olympia and Earls Court, London;



How do you measure Reusability?

UP TO FIFTEEN TIMES?

For assemblies that must be locked in place, Elastic Stop Nuts with fiber locking inserts guarantee a permanently secure grip—plus ample reusability to cover most normal maintenance requirements.

For assemblies that must be disassembled and reassembled five, eight, ten, or more times during normal use, fiber insert Elastic Stop Nuts make the ideal self-locking fastener.

When an Elastic Stop Nut is run on a bolt, the Red Elastic Collar hugs the bolt—actually makes a skin-tight fit against the entire contact length of the threads—and this controlled torque firmly resists vibration or shock. When the Elastic Stop Nut is removed from the bolt, the natural resiliency of the Red Elastic Collar is your guarantee of continuing torque when the nut is reapplied.

MORE THAN FIFTEEN TIMES?

Now, for assemblies that require constant adjustment or frequent disassembly for checking and maintenance, ESNA offers all standard types and sizes of Elastic Stop Nuts with the new nylon locking inserts.

Reusable up to 200 times with remarkably constant torque characteristics, these new Elastic Stop Nuts offer the one-piece construction, the shock resistance, and the moisture-seal features that many manufacturers now depend upon in the standard Elastic Stop Nuts.

One of these Elastic Stop Nuts is probably the solution to your most troublesome fastener problem. It will pay you to look into the self-locking performance of Elastic Stop Nuts. For information, write for a new, free booklet. **Elastic Stop Nut Corporation of America,** 2330 Vauxhall Road, Union, New Jersey.

ESNA
TRADE MARK

ELASTIC STOP NUTS

OVER 450 TYPES AND SIZES IMMEDIATELY AVAILABLE FROM STOCK

and at Castle Bromwich, Birmingham, England. Additional information may be obtained from British Information Services, 30 Rockefeller Plaza, New York 20, N. Y.

May 23-24—

American Society for Quality Control. Fifth annual convention to be held at the Hotel Cleveland, Cleveland, Ohio. Additional information may be obtained from society headquarters, 22 East 40th St., New York 16, N. Y.

May 24-25—

Society of the Plastics Industry. Annual national meeting to be held at the Greenbrier Hotel, White Sulphur Springs, W. Va. W. T. Cruse, 295 Madison Ave., New York 17, N. Y., is executive vice president.

June 3-8—

Society of Automotive Engineers. Summer meeting to be held at the French Lick Springs Hotel, French Lick, Ind. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

June 11-15—

American Society of Mechanical Engineers. Semiannual meeting to be held at the Hotel Royal York, Toronto, Ontario, Canada. C. E. Davies, 29 West 39th St., New York 18, N. Y., is secretary.

June 11-16—

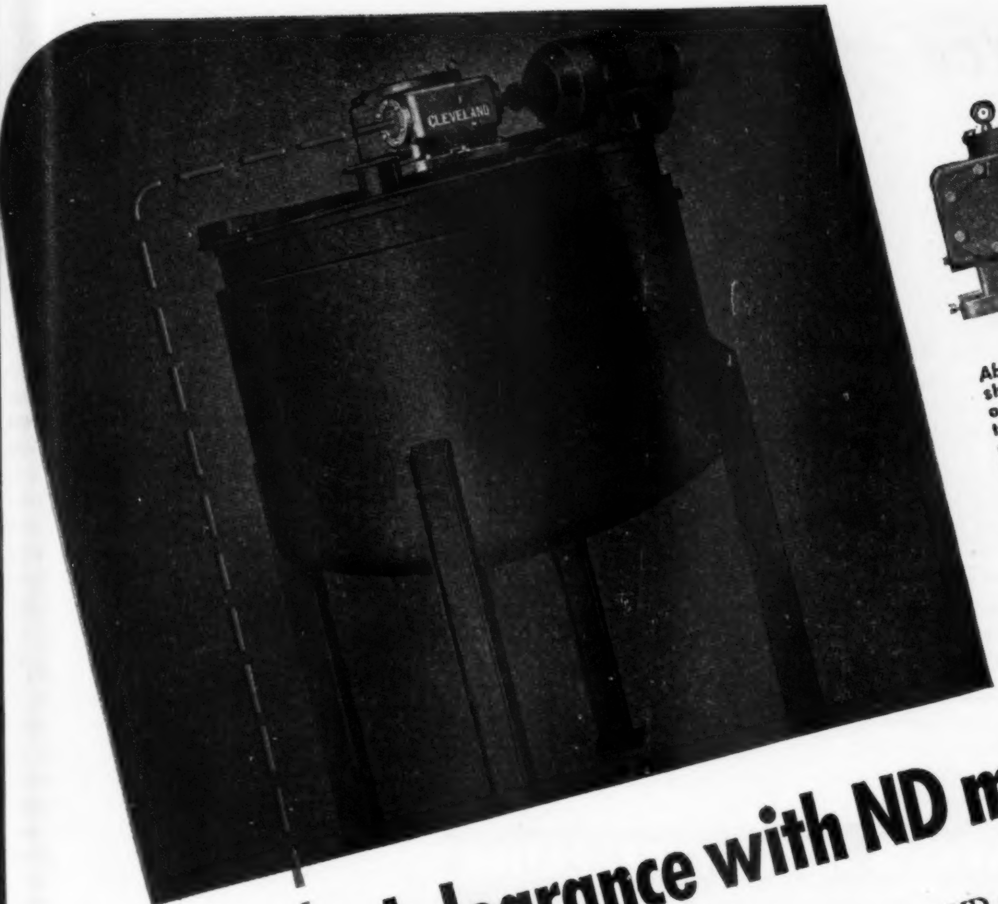
National Congress of Applied Mechanics to be held at Illinois Institute of Technology, Chicago, Ill., under the sponsorship of the ASME, ASCE, AIChE, AMS, APS, IAS, SESA, U. S. National Committee on Theoretical and Applied Mechanics, Illinois Tech, Purdue University, Northwestern University and University of Illinois. Lloyd H. Donnell, Illinois Institute of Technology, 3300 South Federal St., Chicago 16, Ill., is general chairman.

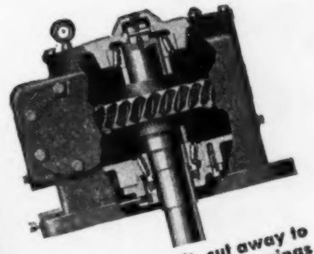
June 18-22—

American Society for Testing Materials. Annual meeting to be held at the Chalfonte-Haddon Hall, Atlantic City, N. J. Additional information may be obtained from society headquarters, 1916 Race St., Philadelphia 3, Pa.

June 25-29—

American Institute of Electrical Engineers. Summer general meeting to be held at the Royal York Hotel, Toronto, Ontario, Canada. H. H. Henline, 33 West 39th St., New York 18, N. Y., is secretary.





Above—ND unit, cut away to show tapered roller bearings on gear shaft, positive face-type oil seal, unique lubricating pump and oil drain at base of housing.

Left—1,000-gallon mixing kettle built by the Water Tube Boiler & Tank Co. for the Pyroxylin Products Co., Chicago, for use in mixing viscous lacquers.

Low overhead clearance with ND mixer drive

AN outstanding advantage of Cleveland's new ND vertical worm gear speed reducer is its low height. Installed on this 1,000 gallon mixing kettle, the ND unit adds only 16 inches to over-all height—no more than that of the motor.

The ND reducer and its companion NU unit (with drive shaft upward) are available in seven sizes each. Because of their several unique construction features, they will give efficient, trouble-free service on such equipment as agitators, mixers, overhead chain conveyors, etc., wherever vertical drives without outboard bearings are desirable.

For complete description, capacity charts and other engineering data on types ND and NU, write for our Bulletin 125. The Cleveland Worm & Gear Company, 3265 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited

CLEVELAND
Worm Gear
Speed Reducers

NEW MACHINES

And the Companies Behind Them

Domestic

AUTOMATIC WASHER: Top-loading machine with agitator action. Automatically washes, rinses and spin dries 9-lb load of clothes and shuts off. Wash cycle followed by flush rinse and deep agitated rinse, with water spun out over clothes, not through them. Powered by ⅓-hp motor through sealed transmission. Positive filling mechanism makes it impossible for washing to begin until tub is filled with required amount of water. *General Electric Co., Bridgeport, Conn.*

HOME FREEZERS: In 15 and 23-cu ft models. Hold 532 and 808 lb of frozen food, respectively; have freezing capacities of 73 and 130 lb every 24 hours. Both models have 3.3-cu ft, 116-lb compartments located over freezing unit for quick-freezing foods, which can then be moved to baskets in storage compartments. *Hotpoint Inc., Chicago, Ill.*

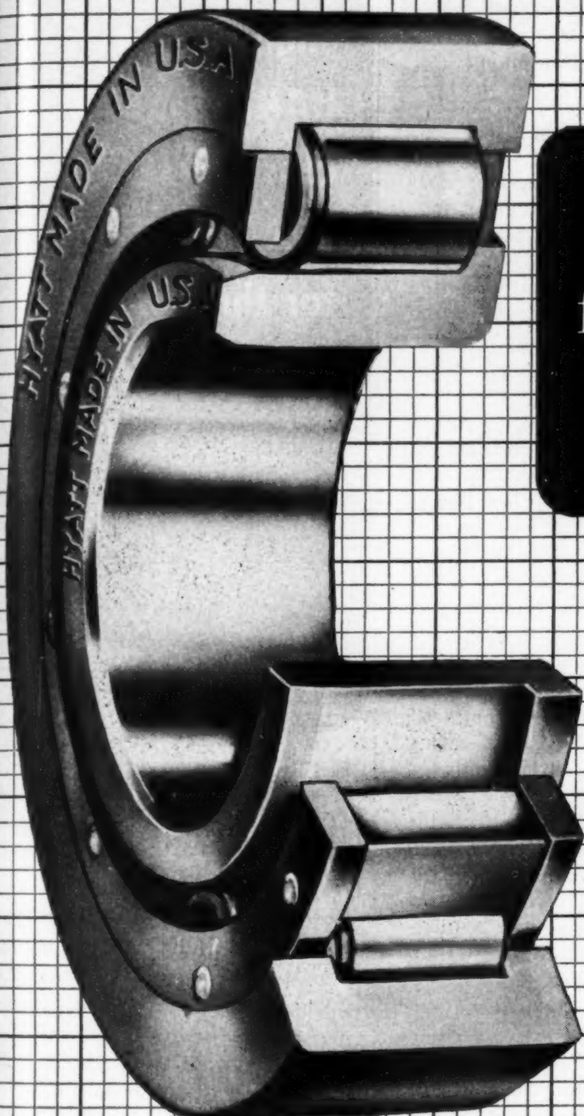
ELECTRIC RANGE: Deluxe, high-back pushbutton range for use as free-standing unit or under conventional cabinets. Has two ovens and broilers, two large surface units and two standard surface units. One of surface units equipped with high speed element for fast cooking starts. Two storage drawers are roller bearing mounted. *General Electric Co., Bridgeport, Conn.*

Heating and Ventilating

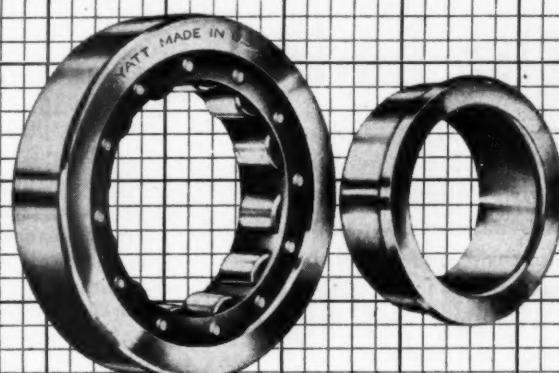
REFRIGERATION UNIT: Hermetically-sealed unit combines advantages of centrifugal design and variable capacity in unit for offices, hotels, apartments, stores and plants. In models for 45 to 190 tons refrigeration. Hermetic sealing of two-stage compressor-motor assembly eliminates shaft seals; direct drive reduces noise and vibration. Pushbutton or thermostatically controlled to modulate, start and stop automatically. *The Trane Co., La Crosse, Wis.*

Heat Treating

ELECTRIC FURNACES: Line of general-purpose furnaces for heat-treating operations at temperatures to 2500 F continuous duty, with higher temperatures available for short or intermittent runs. Series FG models have separate control panel with indicating controller, transformer



Flanged Races for Shaft Location—HYATT HY-LOADS



FLANGED RACES permit "R-WB" Type Hyatt Hy-Load Roller Bearings to locate shafts or gears or accommodate light or intermittent thrust in one direction. Used in pairs, they can locate shafts or accommodate thrust loads in both directions.

The ability to locate shafts and handle light thrust loads is an added feature of this Hy-Load bearing. Its primary advantage is its ability to carry high radial loads.

Hyatt Hy-Load Roller Bearings are adaptable for many bearing installations. There are ten different types, each made in many different sizes to fit almost every application need. Write for your copy of Hyatt catalog 547 for complete information about Hyatt Hy-Load Roller Bearings. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.

HYATT ROLLER BEARINGS

current input meter, and magnetic contactor. Loading areas range from 8 by 10 by 4 in. to 16 by 30 by 12 in. *Pereny Equipment Co., Columbus, O.*

Manufacturing

OSCILLATING GRANULATOR: Of welded stainless steel construction. Designed to eliminate leakage of material, with screen clamped in position in hopper. Worm-drive mechanism sealed in oil. Motor mounted within granulator housing with only end exposed for ventilation. *F. J. Stokes Machine Co., Philadelphia, Pa.*

ARC WELDERS: New series of industrial a-c arc welders for heavy-duty production welding. In 200, 300 and 400-amp capacities. Hipersil steel transformer cores provide 1/3 greater flux-carrying capacity, reduce power consumption and operating costs. *Marquette Manufacturing Co., Minneapolis, Minn.*

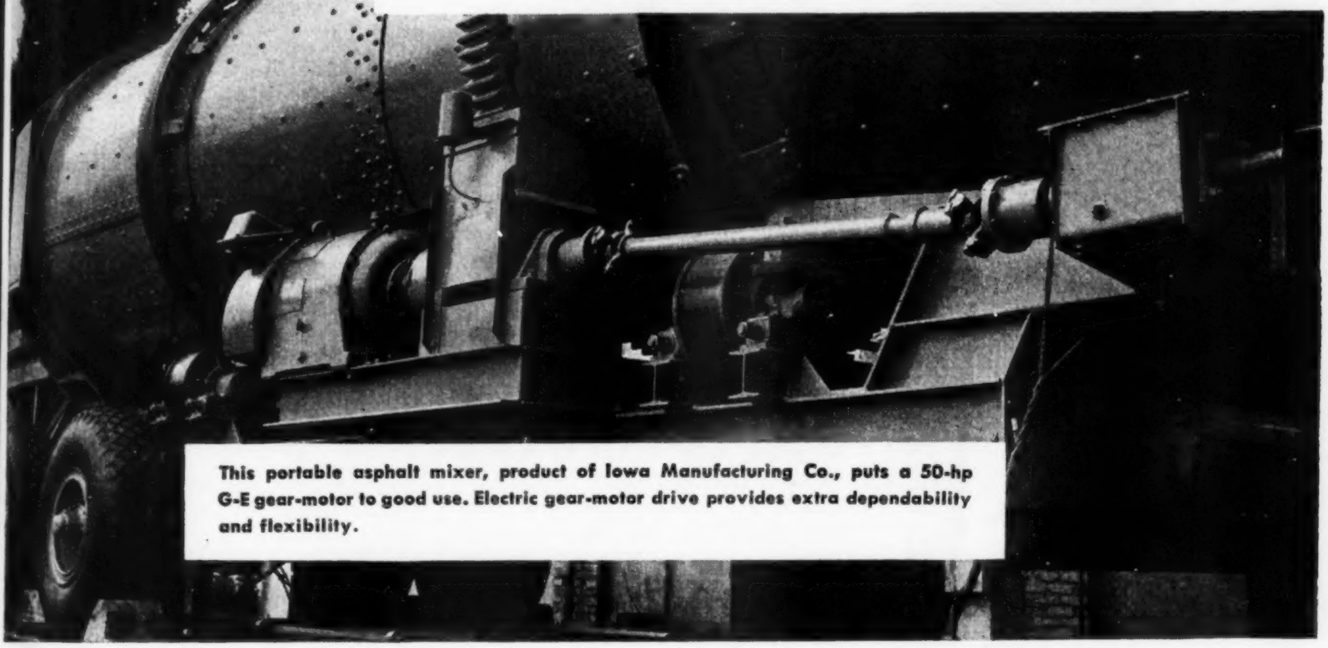
SURFACE GRINDER: Vertical-spindle rotary-table surface grinder equipped with 40-in. diameter magnetic chuck or plain table. Max swing of work or fixture, 49 in. Equipped with three abrasive wheels which can be set to grind the same surface or different surfaces at various distances from center of chuck. Spindles equipped with motors sized according to power requirements of job being handled. Grinding wheels controlled to 0.001-in. by sizing device. *Blanchard Machine Co., Cambridge, Mass.*

GRINDING MACHINE: Double-disk model 2V-18 machine for grinding two parallel flat surfaces, in one operation, on small parts such as coil springs, carbon brushes, ceramic materials, etc. Two 18-in. diameter solid-center abrasive disks each driven by 3 or 5-hp motor. Rotary work carrier with 32-in. diameter made to suit types and sizes of workpieces. Work carrier speed variable between 1/8 and 1 rpm. Outboard bearing under work carrier insures stability. Both grinding wheels adjustable by hand wheels; both wheels tilt for progressive grinding. *The Gardner Machine Co., Beloit, Wis.*

PUNCH PRESS: Rotary punch press with 24-in. throat designed to handle sheets to 48-in. wide. Rotary turret permits operator to select any one of 18 punch sizes. Punch sizes range from 3/64 to 2-in., operate efficiently on nonmetals or steel to 10 gage thickness. *Rotex Punch Co., Oakland, Calif.*

SPECIAL MILLING MACHINE: Balance mills forged steel connecting rods to within 2 grams variation in overall weight. Production rate, 144

Yes! we said gear motors
UP TO 150 HP
for dependable low-speed drive

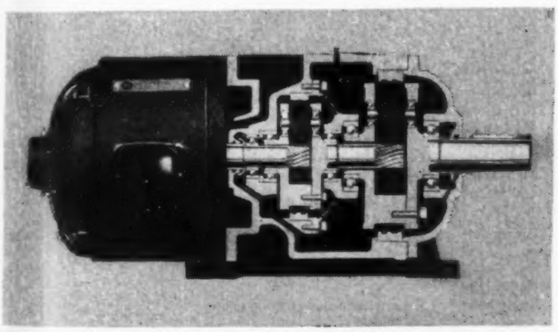


This portable asphalt mixer, product of Iowa Manufacturing Co., puts a 50-hp G-E gear-motor to good use. Electric gear-motor drive provides extra dependability and flexibility.

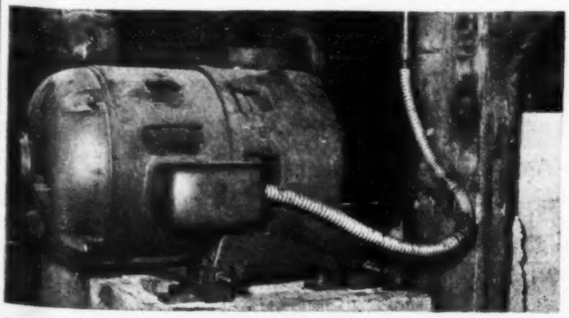
G-E TRI/CLAD GEAR-MOTORS

REG. U.S. PAT. OFF.

compact, efficient, extra-protected



Planetary gear reduction gives you smooth transmission with the greatest load-carrying capacity in the smallest space.



In another asphalt-processing operation, easy starting and smooth operation of this 60-hp Tri-Clad gear-motor are producing substantial savings. The gear-motor replaced a steam-engine drive.

Even for large low-speed drives up to 150 hp, there's a G-E gear-motor that can fill the bill. With it you eliminate separate gears or reducers, because you buy only one compact, pre-engineered power package. You save purchasing and engineering costs by specifying one unit to do the job.

In hazardous areas, too, G-E explosion-proof gear-motors offer extra protection for applications where open gears, belts, and pulleys are prohibited . . . and in addition to these features, you get:

UNIT RESPONSIBILITY—G.E. assumes unit responsibility for both gear and motor, whether it's rated at 1 or 150 hp. You avoid many design and purchasing problems.

PRE-ENGINEERING—G-E gear-motors are pre-engineered to work as a unit, give you the best possible combination of gear and motor for your job.

OVER-ALL PROTECTION—Integrated housing shields the whole unit from dust and dirt, permits application where chains and belts cannot be used.

Standard ratings up to 75 hp are available from stock, and special quotations are issued for ratings up through 150 hp. To fill your needs on all gear-motor requirements, call your nearest G-E Sales Office or your local distributor. Apparatus Dept., General Electric Co., Schenectady 5, New York.

GENERAL ELECTRIC

753-5

pieces per hour at 80 per cent efficiency. Balancing automatically accomplished in one pass. Tool speed is 654 rpm at 300 fpm with $1\frac{3}{4}$-in. diameter tungsten carbide-tipped end mills. Feed is 30 in. per minute or 0.0075-in. per tooth. *Snyder Tool & Engineering Co., Detroit, Mich.*

PORTABLE IMPACT WRENCH: New $\frac{5}{8}$-in. Silver Line universal electric impact wrench for nut setting on heavy equipment. Operating at 2000 rpm, wrench delivers 1850 impact blows per minute, forward or reverse. Weight, 12 lb plus; length, $11\frac{3}{4}$ in. overall. Equipped with detachable handle. Drives machine screws up to $\frac{5}{8}$-in., wood screws to #22. *Independent Pneumatic Tool Co., Aurora, Ill.*

HELIARC TORCH: Lightweight, air-cooled torch for inert gas shielded arc welding. Has two-position welding head and handle assembly weighing only 3 oz. In normal welding position, torch head is at 120-degree down angle from handle. Angle can be changed to 60 degrees backward from handle. Steel collets available for 0.020, 0.040 and $\frac{1}{16}$-in. diameter electrodes. *The Linde Air Products Co., New York, N. Y.*

BENCH LATHE: Second operation lathe equipped with lever-operated collet attachment, lever-operated tailstock and compound slide. Angular adjustments from 22 degrees left to 33 degrees right can be set on front tool slide; includes adjustable dead stops. Driven from 2-speed motor by flat belt with adjustable idler pulley. Complete with $\frac{3}{4}$-hp, 1500 and 3000-rpm motor, $\frac{1}{2}$-in. diameter headstock collet, and $\frac{1}{4}$-in. diameter tailstock collet. *DCMT Sales Corp., New York, N. Y.*

SPECIAL DRILL: For drilling and countersinking cotter pin holes in clevis pins. Capacity, 1500 parts per hour. Employs four automatic drilling units in conjunction with 8-station Geneva type indexing dial and hopper part-feeder. Part countersunk on one side by one unit, drilled by two units and countersunk on other side by other unit. Broken tool stops machine; indexing mechanism will not work unless all tools are out of workpiece. *Govro-Nelson Co., Detroit, Mich.*

INJECTION MOLDING MACHINE: Capacity, 300 oz. Hydraulically operated, with manual and automatic single-cycle control and adjustable speed control of injection ram. Machine has 1500-ton max clamping pressure, platen area to accommo-

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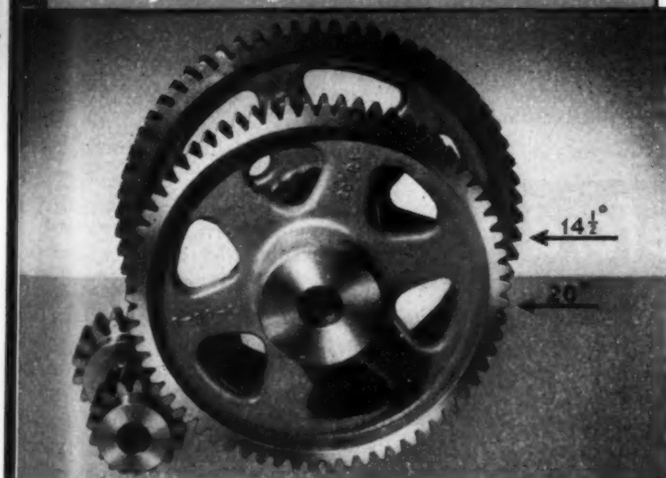

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date 4 by 6-ft molds, 4-ft max stroke, 6-ft daylight opening. Injection and clamping pressures are adjustable. *Watson-Stillman Co., Roselle, N. J.*

AUTOMATIC SCREW MACHINES: Two machines having capacities of ⅞ and 1¼-in. bar stock. Smaller machine powered by 2-hp motor giving eight spindle speeds from 810 to 2500 rpm. Machines capable of producing three operations with simplified tooling and cams. Camshaft driven by separate ½-hp motor. Has 19 feed rates, cycle rates from 12 pieces per minute to 1 piece in two minutes. *DCMT Sales Corp., New York, N. Y.*

SURFACE GRINDER: For toolroom or production work. Has 6 by 18-in. table, provides 12-in max distance between wheel and table. Automatic table cross feed advances table from 0.01 to 0.09-in. at each reversal of table. Uses 7-in. diameter grinding wheel at 360 rpm, requires 1½-hp motor. *DCMT Sales Corp., New York, N. Y.*

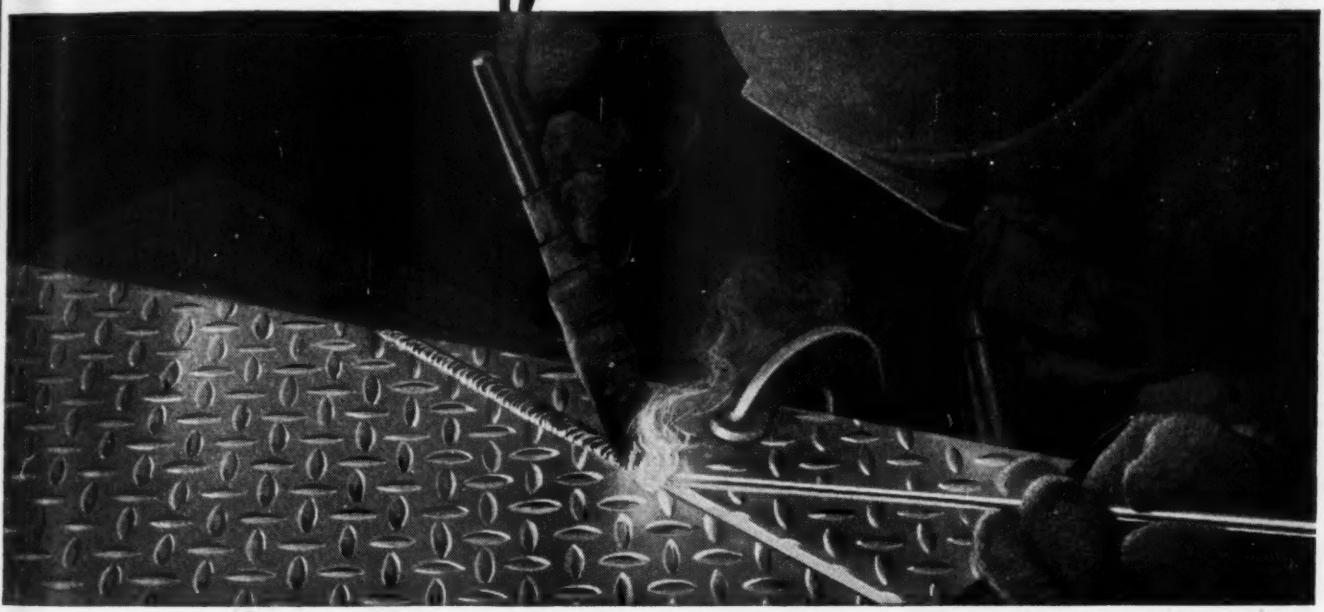
NIBBLER PRESS: Operates at 260 strokes per minute. Punches holes, slots or notches having area of up to 54 sq in. in sheets, strips or plate up to ⅛-in. thick. Punching controlled by template to permit duplication. Throat depth, 20 in. with 4¾-in. clearance; stroke, 1½ in.; max shut height, 3¾ in.; min shut height, 2¾ in.; powered by 1-hp motor. *Service Machine Co., Elizabeth, N. J.*

HONING MACHINE: For finishing bores to 15 in. long, ¼ to 4-in. diameter. Machine carries 1¼-in. diameter steel spindle driven by 3-hp motor, with three speeds available. Two-hp motor drives hydraulic pump for reciprocating spindle at speeds from 1 to 70 ft per minute. Spindle and honing tools hydraulically counterbalanced at all times. Standard height under spindle nose, 40 in. Equipped with pushbutton controls including pushbutton withdrawal at end of honing cycle. *C. Allen Fulmer Co., Cincinnati, O.*

TOOL AND DIE FILER: For filing, honing, polishing and lapping on inner and outer surfaces, and for chafing and sawing. Adjustable stroke permits working in shallow holes. Driven by 10,000-rpm motor rated at 1/10 to ⅛-hp. *Nord International Corp., New York, N. Y.*

SURFACE FINISHING MACHINE: For polishing inside and outside of spoon and fork bowls and similarly shaped small parts. Rack holding parts moves to expose, simultaneously, insides of bowls to small-di-

MAGNESIUM
Can you weld it?



Yes! Magnesium, being the lightest of the structural metals and readily weldable, should be considered whenever light-weight, welded construction is a design requirement. Nearly all of the common welding techniques can be employed. Inert-gas shielded arc welding, gas welding, and electric resistance welding are all being used successfully on magnesium.

Most forms of magnesium are weldable. While joint strengths will vary with different alloys, typical properties of welded butt joints show tensile strengths up to 42,000 psi and elongations up to 12%. Also, magnesium welds are free of microporosity, an important advantage when designing thin walled pressure containers. The combination of relatively high weld strength and minimum specific gravity found in magnesium generally permits designing welded magnesium structures that are lighter, stronger, and more rigid than is possible in other light metals. For more information call your nearest Dow sales office or write direct, Dept. MG-72.

When lightness is important, consider **MAGNESIUM** *first!*

Dockboards, formed from 5/8" magnesium plate are arc welded in production with a single pass.

Magnesium Division, Dept. MG-72

THE DOW CHEMICAL COMPANY
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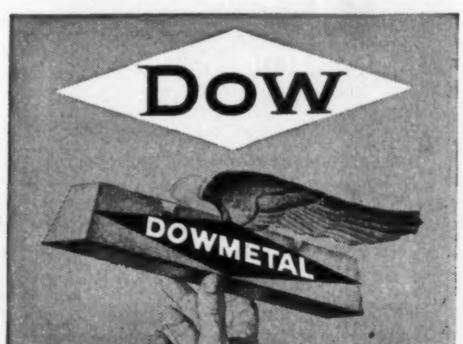


ameter convex buffs and outsides to large-diameter concave buffs. Electro-hydraulic system powers machine, with rolls opened and closed pneumatically. Minimum working area space, 38 in. wide. *Clair Manufacturing Co., Olean, N. Y.*

Materials Handling

ELECTRIC HOISTS: New line of heavy-duty cable hoists in ½, 1, 1½, 2, 3 and 5-ton capacities. Motor totally enclosed within cable drum to reduce overall dimensions, also protecting motor against moisture, dust, etc. Gear reduction is through double internal gear train incorporating two Weston type load brakes. Motor brake is of equalizing solenoid type, connected to up-limit cutoff switch. Safety factor exceeds 6 to 1. *The Cleveland Chain & Mfg. Co., Cleveland, O.*

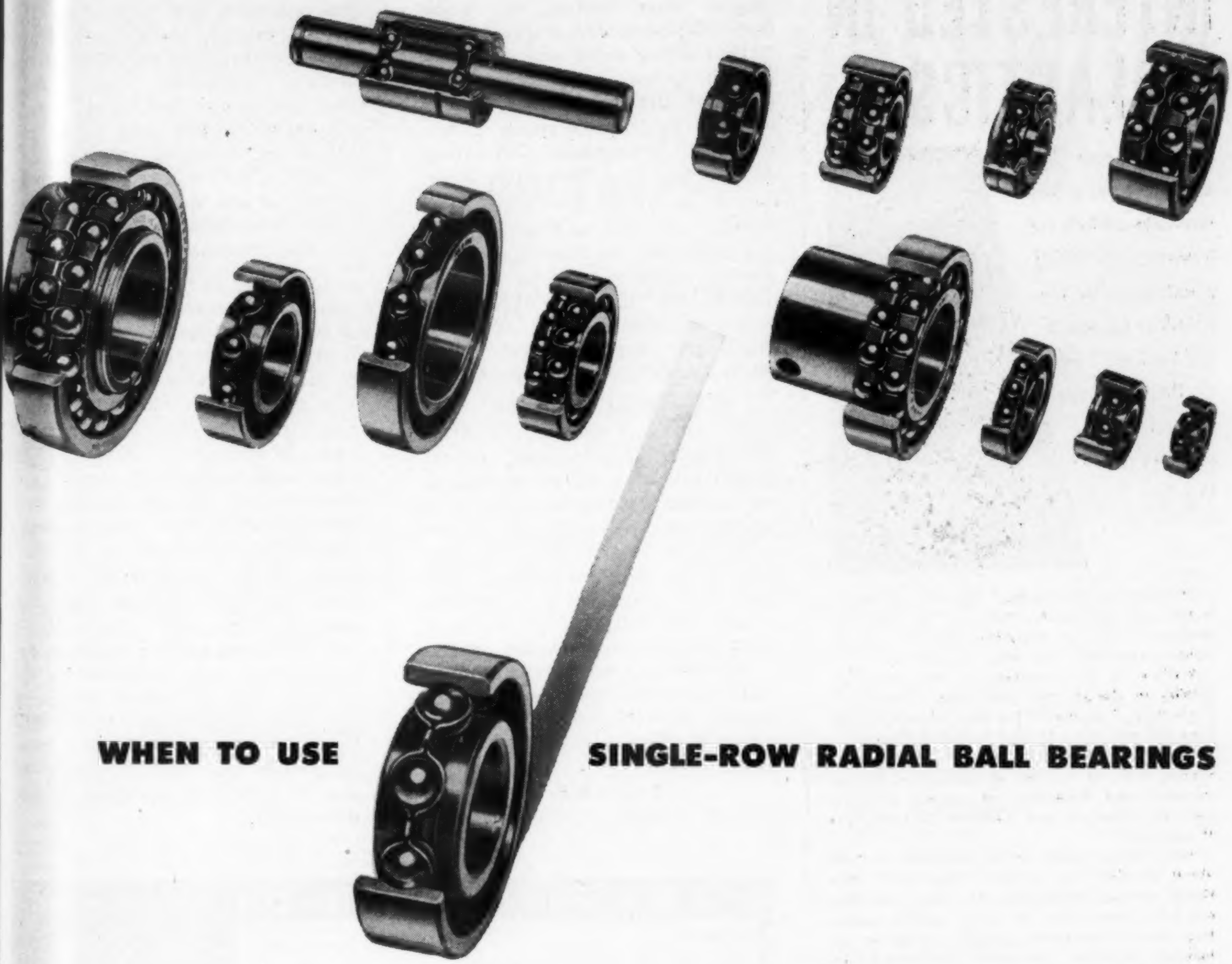
CARGO LOADER: Mobile cargo-handling conveyor unit for air and industrial cargo handling. Consists of 21-ft conveyor mounted on standard Dodge chassis. Conveyor adjustable between 5½ and 11 ft using control next to drivers seat. Belt direction reversible. Folding side rails lower to permit loading or unloading of packages wider than conveyor. Concentrated load capacity, 500 lb; distributed load capacity, 1500 lb. Power takeoff disconnected for highway operation to 25 mph. *Sage Equipment Co., Buffalo, N. Y.*

FORK TRUCKS: Capacities, 3000, 4000 and 6000 lb. Battery-powered trucks have, respectively: outside turning radius of 74, 74 and 81 in.; minimum intersecting aisles, 65, 65 and 70 in.; right angle turn, 90, 90 and 100 in. (plus length of load); overall height, 83 in.; telescoping lift, 126 in.; and initial lift, 63, 63¼ and 61 in. *Baker Industrial Truck Div., The Baker-Raulang Co., Cleveland, O.*

ELECTRIC PALLET TRUCK: Capacity, 4000 lb. Features new contactor panel, positive action brake with dead-man control, improved differential action and all-rubber dual trailer wheels. Operator controls located for operation with either hand. Key switch provides positive turn off to prevent unauthorized use. Lift action is hydraulic. *Towmotor Corp., Cleveland, O.*

Plant Equipment

STEAM CLEANER: For use where steam is available at 80 psi or higher. Speedyjet unit includes high pressure detergent tank mounted on wheeled dolly, 25 ft of high-pressure steam hose leading to



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tank, and 25 ft of steam and detergent hose leading to steam lance. Equipped with pressure gage, 200-psi safety valve and necessary control valves. Solvent, detergent or paint stripper can be applied alone or mixed with steam in any desired proportions. *Livingstone Engineering Co., Worcester, Mass.*

STAPLING HAMMER: For high speed tacking and light nailing. Requires one hand and one blow to seat staples of 0.050 x 0.019-in. wire in several leg lengths. Accelerated driver multiplies force of blow. Parts are plated for rust resistance. *Bostitch, Westerly, R. I.*

Power Plant Equipment

DIESELS: One and two-cylinder Armstrong-Siddeley air-cooled diesels particularly well suited to generator service developing from 3 to 10 kw. Single-cylinder model develops 8 hp at 1500 rpm. Two-cylinder model develops 20 hp at 1800 rpm. Both have 4¼-in. bore and stroke. Furnished with standard SAE bell housing mounted on flywheel cowl to accept standard generator housings. Starters and generators can be supplied if required. *Lister-Blackstone Inc., New York, N. Y.*

Processing

PORTABLE ELECTRIC OVENS: Capable of heating to 225 F in 15 minutes. For industrial uses including: baking of enamels, lacquer, wrinkles and other finishes; for dehydrating bobbins, coil forms, paper tubing, etc.; for drying plastics, etc. Fresh air drawn in and stale air driven out by fan driven by motor outside of unit. Ovens constructed to nest on top of one another. Inside size, 29 by 24 by 20½-in. *Grieve-Hendry Co. Inc., Chicago, Ill.*

Testing and Inspection

WIRE MEASURING GAGE: Automatically controls amount of material extruded around wire. Gage designed to handle any wire diameter up to 1 in. Speeds up or slows down wire speed through extruder. Intermittent irregularities which would cause erratic action in controls are dampened out to give smooth surface on coated wire. *Federal Products Corp., Providence, R. I.*

SORTING GAGE: Automatically sorts bushings for telephone lightning fuse units into four classes. Model 144 B-12 gage handles bushings approximately ½-in. diameter by ¾-in. long. Capacity, about 3600 parts per hour. Bushings are loaded into hopper, with gage depositing them in proper tote box according to size. *Federal Products Corp., Providence, R. I.*

BOOKS
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PLASTICS IN ENGINEERING By John Delmonte. Here's a brand new "how-to-do-it" book of technical data that will help you determine the RIGHT plastic material, the RIGHT mold design and the RIGHT fabricating technique to solve your plastics problem. PLASTICS IN ENGINEERING puts scores of up-to-the-minute facts about plastics right at your fingertips: How strong various plastics are—for what uses they are best suited—how to design plastic parts—how these remarkable synthetic materials are molded, extruded, laminated, cast—how much heat they will stand—how to guard against failure—how to machine plastics—and other vital factors that are so essential to satisfactory plastics performance. Contains 656 pages . . . 168 illustrations . . . 81 tables. Third edition. *Price $10.*

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GATES & RISERS FOR CASTINGS By Pat Dwyer. This book by the engineering editor of The FOUNDRY magazine, has no equal as a source of information on how to eliminate casting defects. Foundrymen will find that it thoroughly covers all the various problems that arise in the design and use of gates and risers. Detailed examples of gates and risers for practically all types of ferrous and non-ferrous castings are described and illustrated. It gives you practical methods of gating gray iron, steel, malleable iron, aluminum, brass and bronze castings. Practically every problem that you can encounter is covered in an easy-to-read text that is accompanied by detailed drawings. This brand new, third edition, contains 384 pages, 247 illustrations, 31 chapters, and is fully cross-indexed. *Price $6.*

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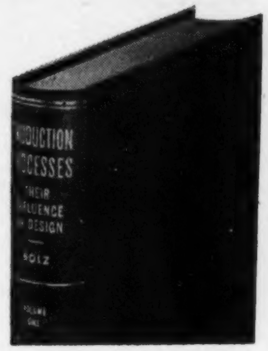
How Much Guesswork Are You Putting into Your Designs?



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